PUBLISHED BY THE INSTITUTE OF FOOD TECHNOLOGISTS

IN THIS ISSUE

C. E. Livingston, W. B. Esselen, E. Feliciotti, D. E. Westcott, & M. P. Baldauf: Quality Retention in Baby Foods Processed By High Temperature-Short Time Methods / *1*

Elizabeth Ann Gardner & Betty M. Watts: Deterioration of Cooked Southern Oysters / *6*

E. Vinset & Walter L. Clark: The Effect of Copper Contamination upon the Development of Color in the Processing and Storage of Honey / *12*

George J. Fuld & Cecil G. Dunn: Automatic Pilot Plant Control in the Development of Microorganisms / *15*

R. T. Whittenberger & G. C. Nutting: Effect of Tomato Cell Structures on Consistency of Tomato Juice / *19*

Daniel C. McCoy: Current Refrigeration Problems of Interest to the Citrus Industry / *23*

W. B. Van Arsdel: The Time-Temperature Tolerance of Frozen Foods. I. Introduction—The Problem and the Attack / *28*

D. G. Guadagni, C. C. Nimmo, & Eugene F. Jansen: The Time-Temperature Tolerance of Frozen Foods. II. Retail Packages of Frozen Peaches / *33*

D. G. Guadagni & C. C. Nimmo: The Time-Temperature Tolerance of Frozen Foods. III. Effectiveness of Vacuum, Oxygen Removal, and Mild Heat in Controlling Browning in Frozen Peaches / *43*

F. Filipello: Organoleptic Wine-Quality Evaluation. I. Standards of Quality and Scoring vs. Rating Scales / *47*

F. Filipello: Organoleptic Wine-Quality Evaluation. II. Performance of Judges / *51*

E. L. Pippen & E. J. Eyring: Characterization of Volatile Nitrogen and Volatile Sulfur Fractions of Cooked Chicken and Their Relation to Flavor / *53*

M. L. E. Florian & P. C. Trussell: Bacterial Spoilage of Shell Eggs. IV. Identification of Spoilage Organisms / *56*

Featuring This Month and Other Departments / *2 and following*

Time-Temperature Tolerance of Frozen Foods

. . . pages 28 to 47

PRODUCT NEWS FROM Pfizer

L-LYSINE

(monohydrochloride)

with NO D-isomer

produced by fermentation... now available in quantity

• Through its leadership in fermentation chemistry, Pfizer now offers pharmaceutical and food manufacturers the essential nutrient L-lysine in practical commercial quantities. A unique fermentation process assures that only the biologically active L-isomer is produced.

In the average human diet lysine is more deficient than any of the other eight essential amino acids.

Volume production of Pfizer L-lysine means you can offer an important new health plus in your products. In medicinal products Pfizer L-lysine should have special significance in meeting the nutritional needs of children, pregnant women, older people and those who are recovering from illness. In cereal food products, particularly wheat products,* Pfizer L-lysine can improve the amino acid balance to a level comparable to that of high quality animal proteins.

Write us if you would like further information about Pfizer L-lysine, and a free sample. Pfizer Technical Service men can also help you in taking advantage of this important new development.

*Before adding L-lysine to food products, manufacturers should check Federal and State standards of identity.

Manufacturing Chemists for over 100 years.

Pfizer

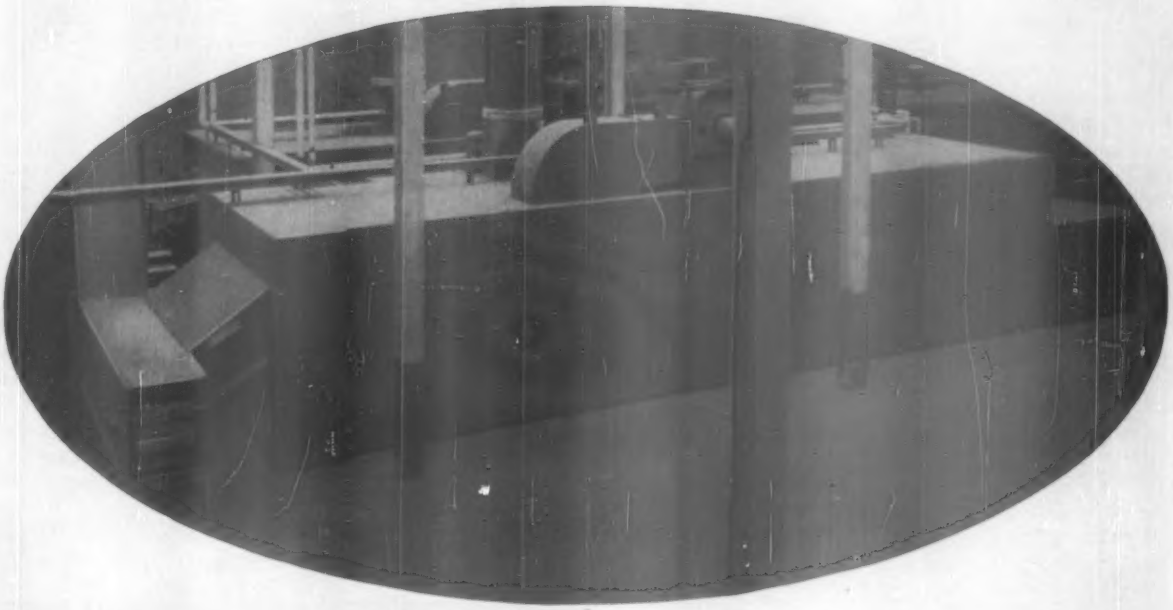
CHAS. PFIZER & CO., INC.

Chemical Sales Division

630 Flushing Ave., Brooklyn 6, N. Y.
Branch Offices: Chicago, Ill.; San Francisco, Calif.; Vernon, Calif.; Atlanta, Ga.; Dallas, Texas

PROCTOR DRYERS

for high product uniformity – more profit!



PRODUCT UNIFORMITY is of utmost importance to every food processor, at all stages of processing. The Proctor continuous conveyor dryer installation shown above is located in a plant of one of the world's largest food manufacturers—typical of many in use in the food industry today. In this plant Proctor Dryers assure uniformity of color, taste, and high customer appeal—yields are greatly increased!

WITH UNIFORMITY COMES PROFIT. Efficient drying per pound of product can often mean more direct profit than an increased sales volume. Proctor equipment provides the control, flexibility and construction features *essential* to profitable drying performance. Write or phone today for complete information.

INCREASED YIELDS

GUARANTEED QUALITY OF PRODUCT

FLEXIBILITY

PROFITABLE OPERATION

OTHER PROCTOR DRYING EQUIPMENT FOR THE FOOD AND PROCESS INDUSTRIES

TRAY DRYERS • TRUCK DRYERS
PRE-FORMING FEEDS • SPRAY DRYERS

Proctor

PROCTOR & SCHWARTZ, Inc.

MANUFACTURERS OF INDUSTRIAL DRYING EQUIPMENT AND TEXTILE MACHINERY
Philadelphia 20, Pa.

FEATURING THIS MONTH . . .

Food Research at the Eastern Utilization Research Branch

Norman E. Roberts
Eastern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Philadelphia 18, Pennsylvania

IN THE SUMMER of 1940, the doors of the Eastern Regional Research Laboratory of the U. S. Department of Agriculture, in Wyndmoor, Pennsylvania (near Philadelphia), first opened. It was one of four laboratories established simultaneously to find new and profitable uses for agricultural commodities. The others likewise took their names from the agricultural regions they were intended to serve; the Northern in Peoria, Illinois, the Southern in New Orleans, Louisiana, and the Western in Albany, California.

These four laboratories are known today as the Utilization Research Branches of the Agricultural Research Service. The research conducted in these Branches is seeking both new industrial uses and new food uses for agricultural commodities. In the food field much of the effort has been directed to the development of new items and to an improvement in the quality or a decrease in the cost of existing foods.

The Eastern Utilization Research Branch is administered by Dr. P. A. Wells, who has been head of the Wyndmoor laboratory since its beginning. The Branch now embraces, in addition to the Eastern Regional Research Laboratory, laboratories in the South Building of the Department of Agriculture in Washington, D. C., and at the Agricultural Research Center, in Beltsville, Maryland.

Broadly, the food program of the Eastern Utilization Research Branch could be divided into three large areas: (1) Eastern fruits and vegetables, and special crops; (2) dairy products; and (3) meat and other livestock products.

Fruits and vegetables. The program of the Eastern Branch on fruits and vegetables ranges from a detailed scientific analysis of the components of fruits and vegetables and similar work of a fundamental nature, to the development of new food products and their production on a small scale in the laboratory's well-equipped pilot plant.

On the fundamental side, for example, there is the study of the red sour cherry, which is designed to find out why this popular pie fruit loses its appealing bright color in a relatively short time after canning.

The minor constituents of fruits and vegetables—

(Continued on page 4)

The Eastern Regional Research Laboratory, Wyndmoor (near Philadelphia), Pa., headquarters of the Eastern Utilization Research Branch of the USDA's Agricultural Research Service. Inset is Dr. P. A. Wells, Chief of the Branch.

MAKES THE TASTE BUDS TINGLE just to look at these eye-filling gelatin dessert delicacies. But *sight appeal* is not enough; your easy-to-prepare dessert products must also possess *luscious, lively flavors* if they are to convert first-time buyers into steady, *repeat* customers for your particular brand . . . FRITZSCHE offers an incomparable selection of fine flavors specially developed for various types of food, beverage and dessert products . . . also the experience and facilities for handling individual flavoring problems that demand special laboratory attention. Remember: *Your product is* ONLY *as good as its* FLAVOR!

For helpful suggestions, direct your special flavoring problems to our Flavor Division, Dept. FT.

FRITZSCHE *Established* 1871 *Brothers, Inc.*

PORT AUTHORITY BUILDING, 76 NINTH AVENUE, NEW YORK 11, N. Y.

BRANCH OFFICES *and* *STOCKS: *Atlanta, Georgia, Boston, Massachusetts, *Chicago, Illinois, Cincinnati, Ohio, *Los Angeles, California, Philadelphia, Pennsylvania, San Francisco, California, St. Louis, Missouri, Montreal and *Toronto, Canada and *Mexico, D. F. FACTORY: *Clifton, N. J.*

(Continued from page 2)

those present in such minute quantities that they could not be accurately determined by earlier analytical methods—are under study at the Eastern Branch by such methods as chromatography and infrared and ultraviolet spectrophotometry. This work is revealing that some of these components of fruits and vegetables have important effects on their processing quality.

Eastern Branch chemists have been interested in what makes for consistency in processed tomato products.

Eastern Branch apple juice powder is kept dry by means of an in-package desiccant, in the small envelope in the center foreground.

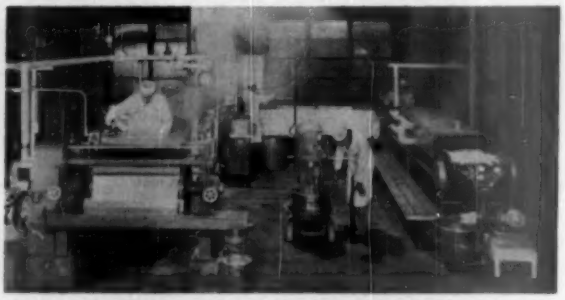
Not sure that the amount of pectic compounds is the only, or even the main, factor in regulating consistency, they have noted vast differences in juices made from different parts of the tomato, which had essentially the same solids and pectic content. These studies have indicated that chemical composition is not so important to juice consistency as the quantity of tomato cell walls present, the presence or absence of pectins in the walls, and the structural arrangement of the walls.

On the applied side, various new products are continually being developed at the Eastern Branch and brought to the point of production feasibility in the Branch's pilot plant. In 1944 a process was developed for making full-flavored apple juice concentrate by recovering the volatile flavor of the apples during processing, concentrating it, and then restoring the recovered and concentrated flavor to the concentrated juice. This basic development, called "essence recovery," is of great importance because it permits the recovery of the volatile flavoring constituents that impart the fresh character to the fruit. These volatiles were previously largely lost during processing. This development opened the way for the economical production of many volatile fruit essences, which are used to restore the flavor to concentrates. They are also used to fortify the flavor of other food products such as ice cream, candy, and beverages, and are incorporated in certain flavoring extracts. The process has been applied to grapes, peaches, strawberries, red raspberries, cherries, blackberries, and low-bush blueberries. Apple, cherry, and grape juice powders, produced by a batch process on a pilot-plant scale have successfully withstood room temperature storage tests for over a year without significant flavor or quality loss. A continuous process is now under development to make these powders.

One of the Eastern Branch's latest developments is a new and different form of dehydrated mashed potato called "potato flakes." These flakes are made by drying mashed potatoes in a thin sheet on drum driers and then breaking the sheet into flakes. The process employs a single stage drying step, and the drying time is short (less than 30 seconds). Therefore the potato flavor is retained and a subtle baked-potato flavor is added. Because only a minimum of damage to the cellular structure of the potato occurs, the flakes reconstitute with hot water and milk to mealy, fluffy mashed potatoes.

From the standpoint of the economic utilization of an agricultural commodity often in serious surplus, potato flakes are a promising development. They can be made with lower-solids-content potatoes from the East and other regions as well as from Idaho Russets which are used almost exclusively in other forms of dehydrated mashed potatoes. Also, the process can use single-drum driers, generally available in potato flour plants.

Potato-chip manufacturers can now offer to the public a completely new line of wholesome and nutritious snack items as a result of research at the Eastern Branch on the deep-fat frying of vegetables. Details of processes for making chips from sliced carrots, beets, and parsnips, and "nuggets" from whole peas and lima beans, have been worked out. The chips retain the characteristic flavor of the vegetable from which they



Pilot plant equipment for producing potato flakes. The sliced potatoes are cooked in the steam-tunnel at the right as they move along the conveyor, and after cooking are riced and stabilized by addition of antioxidant (right center). The potatoes are then spread on a steam-heated drum drier and come off the drier in a thin sheet which is broken into flakes (left center).

were made; the nuggets have a unique nutlike flavor. The nuggets also can be ground into soup powders that reconstitute quickly in hot water. Along with the development of these new products, research to improve the quality of the time-honored potato chip is also carried on at the Eastern Branch.

Maple and honey. Maple and honey are two special crops of considerable agricultural significance on which

(Continued on page 6)

FOOD TECHNOLOGY

Published Monthly by the Institute of Food Technologists

Editor

MARTIN S. PETERSON

Editorial Office: 11606 South Bell Avenue, Chicago 43, Illinois

Consulting Editor

Z. I. KERTESZ

Editor Emeritus

C. OLIN BALL

Associate Editors

C. D. ATKINS
JOHN C. AYRES
HAROLD A. CAMPBELL
LIONEL FARBER
RICHARD H. FORSYTHE
DEAN FOSTER
SAMUEL A. GOLDBLITH
C. HAMILTON KENNEY
AMIHUD KRAMER
ROBERT A. LARSEN
FRANK A. LEE
GIDEON E. LIVINGSTON
R. E. MORSE
J. ORVIN MUNDT
WILLIAM RAMAGE
WILLIAM P. RATCHFORD
F. H. REUTER
J. G. WOODROOF

ADMINISTRATIVE DATA AND DIRECTORY

Office of the Editor

11606 South Bell Avenue, Chicago 43

Address to this office all manuscripts, proofs, letters pertaining thereto, etc. Prospective contributors are invited to send for the pamphlet *Information and Suggestions to Authors* which contains style instructions.

Responsibility for statements appearing in FOOD TECHNOLOGY rests on the author thereof; points of view expressed in the columns of the journal do not necessarily have the endorsement of the Institute of Food Technologists. Mention of commercial products in the technical pages of this Journal is not to be construed as a recommendation of such products over others in the same category.

Business Manager

CHARLES S. LAWRENCE

176 West Adams Street, Chicago 3, Illinois

Address to the business office all requests for subscriptions, changes of address, and information on advertising. Claims for copies lost in the mails must be received 30 days after issue (90 days, foreign). Changes of address must be received at least two weeks before date of issue.

Subscription Rates: For members the cost of subscription is included in the annual dues. Non-members: domestic, $8.50 per year; Canada, Cuba and Mexico, $10.00 per year; all other foreign, $12.00 per year. Single and back copies: domestic, $1.50; foreign, $1.75.

Advertising Representatives: *Eastern:* Duncan Macpherson, 126 Summit Avenue, Jenkintown, Pa. *Midwestern:* Dale McCutcheon & Co., 154 E. Erie Street, Chicago 11, Illinois. *West Coast:* William A. Ayres Company, 233 Sansome Street, San Francisco 4, California.

Publication Office

The Garrard Press

119 West Park Avenue, Champaign, Illinois

Address to the Publication Office all requests for non-member subscriptions, back volumes, single copies (costs are listed above). Authors desiring reprints should address orders to this office; rates are printed on the order blank. (Requests for a single reprint of a published paper should be addressed to the author.)

FOOD TECHNOLOGY is published by the Institute of Food Technologists and printed by the Garrard Press, Champaign, Illinois, U. S. A.

Copyright, 1957, by the Institute of Food Technologists.

Mailing Permit: Entered as second-class matter, Feb. 25, 1947, at the Post Office at Champaign, Illinois, under the Act of August 24, 1912.

NIAGARA "NO FROST"

25 Years' Successful Experience

★ Always full capacity refrigeration and freezing.
★ "No Frost" removes moisture as fast as it condenses.
★ Save power, reduce costs; protect frozen food quality.

Write for Niagara Bulletin 105

NIAGARA BLOWER COMPANY

Dept. F. T., 405 Lexington Ave. New York 17, N. Y.

District Engineers in Principal Cities of U. S. and Canada

Try a sample of this wholesome emulsifier

It's DPi's Myverol® Distilled Monoglycerides. And it's not only an excellent emulsifier, but a wholesome food as well.

Made from your choice of natural fats and oils and purified by molecular distillation, it contains at least 90% monoglycerides—is largely freed of diglycerides and other extraneous materials. The product is homogenized with nitrogen to produce a smooth, white cream of dependable uniformity.

Useful for baked goods, shortening, margarine, peanut butter, dessert toppings, and other food products, Myverol Distilled Monoglycerides are available in whatever quantities you require. We shall be pleased to send you a selection of samples for your investigation. Just write *Distillation Products Industries,* Rochester 3, N. Y. Sales offices: New York, Chicago, and Memphis • W. M. Gillies and Company, Los Angeles, Portland, and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

distillers of monoglycerides made from natural fats and oils

DPi

Also . . . vitamin A in bulk for foods and pharmaceuticals

Distillation Products Industries
is a division of **Eastman Kodak Company**

(Continued from page 4)

work is done at the Eastern Branch. Maple processing, from the tapping of the trees to the manufacture of maple sirup, candies, and other products, is intensively studied, with the result that farmers are realizing more from their maple crops and consumers are provided with new, improved, and more economical maple delicacies. Honey research has developed new uses for this sweetening agent, especially in the field of baked products. The constituents of honeys from different floral sources are now being determined by modern analytical techniques.

Dairy products. The Department of Agriculture's utilization research program on milk and other dairy products is concentrated in the Eastern Branch. It is a well-balanced program of both basic and applied studies. The milk-processing pilot plant at Washington did pioneer work in the development of a high-temperature, short-time method of sterilizing evaporated milk. A whole milk powder is under study, new uses for skim milk and whey are in development, and a small-scale bakery evaluates the effectiveness of milk products for baked goods.

L V. Rogers of the Branch's Dairy Products Section demonstrates research on the effect of dried milk solids on bread. Here he is measuring the volume of a loaf by displacement of small seeds.

The total solids content of a milk sample can now be determined precisely without drying it to constant weight, thanks to a new lactometer, developed at the Eastern Branch, which measures the specific gravity of milk at 102° F. At this temperature the fat is completely in a liquid state and thus cannot affect the accuracy of the measurement.

Research on the spreadability and flavor of butter and on the making of many types of cheese is another important part of the Eastern Branch's dairy program. Developments in this field include a new, short-time method of making Cheddar cheese using conventional equipment.

Such practical developments as these are necessarily dependent upon basic research findings. For a number of years the proteins of milk, especially casein, the principal protein, have been studied at the Eastern Branch with highly interesting and significant results. An analysis of the effect of heat on milk has yielded

(Continued on page 8)

Vitamins and the violinists

In the middle is Raymond W. Albright, our general manager. The two musicians are members of our city's orchestra. Mr. Albright, board chairman of the Civic Music Association, has been talking to them about the need for getting more engagements to make ends meet. Tough problem.

A beautiful idea hits the bass violinist. He asks Mr. Albright if it's true his company makes vitamins. Mr. Albright admits it's true. A light goes on in the musician's eyes. Doubtless the vitamins have to be advertised in a dignified way? Why not, he wants to know, use the orchestra on television? Income for the orchestra, more vitamin business for DPi—a living for all!

Sadly, kindly, Mr. Albright explains that we don't advertise our vitamins to the general public. We just supply vitamin A in bulk to margarine and other manufacturers and tell them everything we've learned about the vitamin in the last twenty years. If there is any advertising or promotion of the merits of the vitamin, it must be left strictly up to them. The violinists shake their heads and sigh and go back to rehearsal. Mr. Albright, still with a musical budget problem, goes back to the shop.

If you have any ideas on how to get adequate support for symphony orchestras, Mr. Albright will welcome them. If you have any problems involving the use of vitamins A and E in pharmaceutical products, we'll welcome those too. Even orders. That's the business of ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York, Chicago, and Memphis • W. M. Gillies and Company, Los Angeles, Portland, and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

leaders in research and production of vitamin A

DPi

Also . . . vitamin E . . . distilled monoglycerides . . . some 3500 Eastman Organic Chemicals for science and industry

Distillation Products Industries *is a division of* **Eastman Kodak Company**

(Continued from page 6)

information of value in the field of milk sterilization. The colloidal properties of fat-free milk have been studied using the ultracentrifuge, and this work has clarified many of the changes that take place in manufacturing evaporated milk.

Meat. Meat research at the Eastern Branch is concerned with a number of problems relating to the quality of meat and processed meat products. The perishability of cured meats has led to a study of farm and locker plant methods for curing and storing pork. Improved curing methods have been developed as a result of this research, but more data are being sought on such points as the mechanism of aging and the role of native enzyme systems and microorganisms during curing and storage.

The muscle components of meat are being studied in connection with comminuted products such as sausage. These components have been linked to the "binding" properties of meat which are important for retention of moisture, adherence of components, and juiciness and tenderness in such products.

Beef tenderness is another important field of research at the Eastern Branch. The problem is to take full advantage of the tenderizing effect of aging on lower grades of beef without encountering microbial growth. Among the experiments being tried are ultraviolet radiation to reduce contamination by microorganisms, use of higher aging temperatures, and infusion of carcasses with antibiotics and enzymes. Other qualities desirable in meats, such as juiciness, aroma, flavor, and color, are being studied from the standpoint of the individual meat components which contribute to these qualities.

The Eastern Branch is carrying on an extensive program of research on animal fats. Most of this work is concerned with the use of inedible fats in industrial applications. A part, however, is designed to improve the physical characteristics of lard and other meat fats especially for use in baked products. By means of photomicrography, basic studies are being made on the crystal habit of lard and rearranged lard. This work is expected ultimately to place meat fats in a better competitive position with respect to vegetable shortenings. The Branch is also cooperating in an effort to establish the role of dietary fats in nutrition.

CONCLUSION

Thus, on many food fronts, the utilization research of the U. S. Department of Agriculture, and specifically that of the Eastern Branch, is finding new outlets for the farmer's commodities, providing the food processor with profitable items for manufacture and sale, and widening the consumer's choice of available foodstuffs.

IFT REGIONAL SECTIONS . . .

SPEECHES, SPECIAL EVENTS, NEWS NOTES

CHICAGO . . .

The Section met on December 10, 1956, for dinner at the Palmer House. The December meeting followed tradition as "ladies' night." After dinner the group heard Dr. Ernest Guenther, vice-president and director of Fritzsche Bros., present the story of essential oils. The presentation was based on a motion picture film, in color, showing the production of oil of lavender and lavandin in Southern France; absolute of rose, jasmine, and orange flowers in the Grasse region of the same country, the production of oils and their distillation in Spain—thyme and rosemary, for example—the distillation of pine needle oils (the Tyrol) and the production of lemon and bergamot oils in Calabria and Sicily. New developments in North Africa were also depicted. The countryside of these various regions was a most enjoyable aspect of the film but in addition Dr. Guenther's presentation provided the audience with a wealth of details on the aromatic plants and their constituents. Dr. Guenther, author of the monumental six-volume work, *The Essential Oils*, has accumulated a vast knowledge of his subject. A graduate of the University of Zurich, Switzerland (Ph.D., 1920) he studied under Professor Paul Karrer, Nobel prizeman and outstanding chemist, and began his career in the essential oils field as assistant to Professor Albert Hesse.

NORTHEAST . . .

Ninety-five members and guests attended the November dinner meeting at the M.I.T. Faculty Club, Cambridge, Mass. The evening's festivities started with the presentation of the Florasynth Award for 1956 to Mr. Thomas L. Fazzina, Department of Food Technology, M.I.T., by Col. Charles S. Lawrence, Executive Secretary of the I.F.T.

The featured speaker of the evening was Dr. Emil M. Mrak, Chairman of the Department of Food Technology, University of California, and President-elect of the I.F.T., 1956-57. His illustrated talk dealt with food technology in Switzerland and covered such topics as wine making, apple juice production, cheese manufacturing, slaughter house sanitation, and supermarket operations. Dr. Mrak emphasized that despite the overall small scale type of operation prevalent, the Swiss were very sanitation conscious. This was noted in the frequent use of tile for processing and storage areas devoted to wine making and apple juice and in the rapid

(Continued on page 10)

How Sunkist helps you...

In every field of food processing, new contributions are being made toward tomorrow's better foods. Look at these typical Exchange Brand developments, based on 50 years of Sunkist research.

EXCHANGE
OIL OF LEMON

Unmatched quality and flavor that come only from quality California lemons... grown and skillfully processed by exacting Sunkist standards. The 4-to-1 favorite over all other lemon oils combined!

EXCHANGE
PRESERVER'S PECTIN

Here is even jell strength that guarantees a more consistent, uniform, finished product... a smooth, perfect texture and complete reliability in setting control.

EXCHANGE
LOW METHOXYL PECTIN

A natural fruit pectin that jells without sugar. Completely tasteless, permitting the use of the most delicate flavors... allows the natural juicy fruit flavor to come through. Controls "running" or "weeping" in pies when cut. Famous too for aspics, jellied fruit or vegetable salads, dietetic preserves or non-sugar jells.

EXCHANGE
OIL OF ORANGE

By far the best orange oil by any laboratory measurement. Always consistent, richer in flavor strength and more intense in aromatic constituents. Standard the world over for orange flavor excellence.

EXCHANGE
LEMON JUICE

Brings out the natural flavor of any food product. A superior acidulant in the preparation of mayonnaise, fruit cocktail, figs, fruit nectar, prunes and other heavy-syrup products. Highly effective as an anti-oxidant in processing frozen foods, particularly frozen fish products. Available in concentrated or single strength form.

Sunkist Growers

Exchange

PRODUCTS DEPARTMENT • ONTARIO, CALIFORNIA

(Continued from page 8)

sanitary cleanup of outdoor slaughtering pens. While the outdoor type of market place for edibles still is an integral part of Swiss community life, the American type of supermarket is becoming increasingly important.

Florasynth Award (left to right): Jack Friedman, Vice President, Florasynth Company; Arch Payne, General Manager, Florasynth Company; Thomas Fazzina, M. I. T., the recipient; Dr. Samuel A. Goldblith, executive officer, Dept. of Food Technology, M. I. T.; Col. Charles S. Lawrence, Executive Secretary, IFT; Dr. Bernard E. Proctor, Head of the Department of Food Technology, M. I. T.

OREGON . . . .

The Oregon Section, IFT began their November 2 meeting activities with a late afternoon tour of the new Portland glass plant of Owens-Illinois. Among the hosts welcoming the group of approximately sixty were Bill Spencer and Marshall Bull. An after dinner meeting with Pres. Alton McCully presiding was held at the Kitchen Kettle at which IFT President-elect Emil Mrak brought news from the national office and presented graduate student John Schnautz with the General Foods plaque which accompanies the award fellowship, previously announced.

Presentation ceremony for the General Foods Award, 1956, to John A. Schnautz (3rd from left), graduate student, Chemical Engineering Department, Oregon State. Dr. Emil M. Mrak, IFT president-elect (far right) presents the plaque that signifies the winning of the $4,000 per annum academic prize while Dr. H. W. Schultz, Head, Food Technology Department and Professor J. S. Walton, Head, Chemical Engineering Department, OSC, look on with interest and approval.

The feature of the meeting was the talk of Dr. Mrak on "Developing Concepts of Food Technology Teaching and Research." This was well received by both those in industry and those in education, for the impact of theory upon industrial problems was well illustrated in the operational organization of university Food Technology research and teaching. The relationship of the fundamental sciences and various other studies in a Food Technology Department was explained. The well-equipped young Food Technologist who is graduating today is better trained than ever before to define and handle the problems of today and tomorrow.

WESTERN NEW YORK . . . .

The Peace Bridge Motel, Buffalo, N. Y., was the scene of the Section's December 3rd meeting. Dr. George Garnatz, IFT President, was the dinner speaker and his topic was "Kroger Foundation—Consumer Research." Dr. Garnatz is the Foundation's Director. The afternoon was devoted to a technical program and the following papers were heard:

"Report on Studies Relating to the Quality of Freestone Peach Purees as Affected by Harvesting and Processing Conditions," by Dr. D. E. Wilson, New York State Agricultural Experiment Station, Geneva, N. Y.

"The Structure and Properties of Present Day Food Colors"—by Dr. Samuel Zuckermann, Plant Manager, H. Kohnstamm & Co., Inc., Brooklyn, N. Y. (Dr. Zuckermann will discuss the fundamentals of this new technique, and possible adaptability to food technology will be noted).

"Radioactive Isotope Tracer Techniques"—by Dr. Gordon Harris, Chairman of Department of Chemistry, University of Buffalo, Buffalo, N. Y.

PHILADELPHIA . . . .

IFT President George Garnatz addressed the Section's November dinner meeting held at the Drexel Institute of Technology on the 13th. Topic: "Newer Trends in Food and Effects on Our Eating Habits."

Mr. Garnatz, with the aid of projected slides, outlined the development of our knowledge of food throughout the history of food technology. For instance, in the early days up to 1834 food was considered to be merely a combination of protein, fats and carbohydrates. In the relatively short space of about 100 years we have come to realize the need of specific vitamins, amount of calories, trace minerals and about 50 to 60 recognized nutritional factors. He also related how the development of new and different foods, new processing and new trends in food habits are affecting the food industry. Today we find the need for special dietary foods for the aged and the infant, enriched foods, prepared frozen heat-and-serve platters and prepared mixes. With these innovations the lady of the house now spends on the

(Continued on page 12)

CONTINENTAL *Landmarks*

Periodic progress reports of interest and value to the packing field

New Savorlock cans for hygroscopic products combine long shelf life and positive reseal

Intended to spur impulse sales of instant coffee and other "hard-to-hold" products, Continental's newly announced Savorlock cans are believed to be the first of their category to be made on high-speed lines for maximum economy.

Eye appeal is provided by brilliant lithography, plus unusual package proportions, established on the recommendation of a well-known industrial designing firm. The two sizes — 204 x 315 and 305 x 507 — are pleasing in appearance, while getting as many units as possible into each running foot of shelf space. Additionally, the lightweight cans stack securely.

Intensive store evaluations show no appreciable moisture pickup four months after stocking. After tamper-proof glassine inner seal is broken, the lock top gives a positive reseal in day-to-day home use.

Supermarket time studies reveal it takes a shopper an average of 4 seconds to choose an item from a grocery shelf. New Savorlock cans, in 2 and 6-oz. capacity, are specifically designed for today's impulse buying.

PERTINENT DATA ON THE NEW Savorlock CANS

The full opening and positive resealing features recommend Savorlock for almost any powdered or granulated product, food or non-food. Evaluations have been confined to instant coffee as being one of the most hygroscopic of food products now marketed. Other products for which tests can be arranged include:

- Soluble tea and tea bags
- Chocolate and cocoa
- Non-fat dry milk
- Dehydrated soups
- Prepared chocolate mix
- Baking powder and soda
- Spices
- Vegetable flakes
- Brown and confectionery sugar
- Peanut butter
- Pharmaceuticals
- Laundry starch, bleach

Also instant gravy mix, bouillon cubes, powdered egg whites, dry coconut, prepared dips for fried foods, bread crumbs, hard candy, cookies, dessert powders, dry rice, instant potatoes, etc.

CONTINENTAL CAN COMPANY

Eastern Division: 100 E. 42nd St., New York 17
Central Division: 135 So. La Salle St., Chicago 3
Pacific Division: Russ Building, San Francisco 4
Canadian Division: 5595 Pare St., Montreal, Que.

(Continued from page 10)

average 1½ hours in the kitchen preparing food as compared to 5½ hours only thirty years ago.

In the future, he reported that we can look for more efficient streamlined processes, preservation of more foods with antibiotics, radiation sterilization, more rapid curing of meat, more frozen baked products and a great deal more automation.

In conclusion Mr. Garnatz stated that much has been accomplished in food technology but stressed the need for this information to be disseminated to the public. He suggested that the IFT undertake a program to inform the layman of the influence that Food Technology, as a profession, has had on the many advances made in the vast food industry.

Featured speaker of the November meeting of the Section was Mr. George Garnatz who spoke on the subject: "New Trends in Food and Effects On Our Eating Habits."

In a non-technical style the advances made to date in the processing of foods were reviewed. Included were developments in the preparation of bread, prepackaged meat, accelerated aging of beef and accelerated curing of ham and bacon. The effects of progress in mechanical refrigeration and transportation on the quality of fresh produce were covered as well as improvements in canned foods. Developments in the field of frozen foods were inventoried and also those of fats and oils and prepared mixes.

In addition, he spoke on current trends in research on foods, for example, aseptic canning and cold sterilization. Their implications for the future were considered.

Mr. Garnatz is director of the Kroger Food Foundation in Cincinnati, and active in many national technical societies. As President of the Institute of Food Technologists, Mr. Garnatz also brought us up to date on the affairs of the society.

At the December meeting Dr. David W. Anderson, Director of Research of the Prescription Product Division of the Borden Co., spoke to us on the subject of: "Allergic Foods of Interest to the Food Technologists." In view of the surprisingly vast numbers of people allergic to one or more foods this topic was of great interest to the food technologists as well as the guests.

AUSTRALIA NORTHERN . . . .

On October 24th, the Section inspected the Sydney works of Australian Glass Manufacturers' Company Pty. Ltd. The members who attended were impressed by the large scale of operations and by the extent to which automatic machines were used. This inspection was the forerunner of a number of similar events organised by the Section.

On November 30th a visit was made to the country Cannery of Gordon Edgell & Sons Ltd. at Bathurst, N.S.W. In the new year inspections will be made of Tooheys Brewery and of the Homebush Laboratories of the Division of Food Preservation, Commonwealth Scientific and Industrial Research Organisation.

On the weekend of February 2nd-4th, a visit will be made to the Snowy Mountains to see the progress on the Hydro-Electric Scheme which is expected to boost food production in New South Wales and Victoria.

PITTSBURGH . . . .

The 31st official meeting of the Section was held on November 13, 1956, at the Royal York Apartments Dining Room. The Executive Committee appointed a Constitution Committee to have the local section incorporated. Dr. B. R. Suri, Chairman of Publicity Committee, gave the report on the publicity program. He suggested that each member regularly attending the meetings should bring another member who is not in the habit of attending the meetings and should also contact members of the food industry to arouse interest in our section.

Mr. William A. Scarlett of Minneapolis-Honeywell Regulator Co., Inc. was the guest speaker. His topic was "The Role of Instrumentation in the Food Industry." Mr. Scarlett discussed many of the quality aspects of food which can be recorded and controlled in instrumentation. They included texture, consistency, color and clarity, specific gravity, and refractive index. All of these aspects of quality can be recorded and the information can even be teletyped to a central location many miles away. Mr. Scarlett gave us an interesting prediction. Instruments will eventually be able to record changes in flavor, in his opinion, and nuclear emissions will be used for analysis of butterfat in milk.

PERSONNEL

An honorary degree of Doctor of Science has been awarded to Morris C. Matt, chief chemist, Abbots Dairies, Philadelphia, by the Philadelphia College of Pharmacy and Science for outstanding accomplishments in the field of dairy science.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1957

January 21-24	Annual Winter Meeting of the National Macaroni Manufacturers Association, Flamingo Hotel, Miami Beach, Florida
February 12-14	Technical School for Pickle Manufacturers, Kellogg Center, Michigan State University, East Lansing, Michigan
February 15-17	Institute of American Poultry Industries 28th Fact Finding Conference, Municipal Auditorium, Kansas City, Missouri
February 26-27	Fifth Annual National Dairy Conference, Kellogg Center, Michigan State University, East Lansing, Michigan
April 23-25	Annual Meeting of the Research and Development Associates, Food and Container Institute, Inc., Jefferson Hotel, Richmond, Virginia
May 12-16, '57	**Institute of Food Technologists, Seventeenth Annual Meeting, Pittsburgh, Pa.**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

"Labeled for quality"
...the FLORASYNTH label is your primary assurance of TRUE FRUIT FLAVORS that will start your finished products on the salesway to success...
FLORASYNTH LABORATORIES
INCORPORATED
NEW YORK
ONE GALLON
TRUE FRUIT STRAWBERRY
and other natural flavors
FOR MANUFACTURING USE ONLY
Florasynth LABORATORIES, INC.

EXECUTIVE OFFICES: 900 VAN NEST AVE., (BOX 12) NEW YORK 62, N. Y. • CHICAGO 6 • LOS ANGELES 21

Cincinnati 2 • Detroit • Dallas • Memphis • New Orleans 12 • St. Louis 2 • San Francisco • San Bernardino

Florasynth Labs. (Canada Ltd.) • Montreal, Toronto, Vancouver, Winnipeg • Agts. & Dist. in Mexico: COMSOLMEX S.A. Mexico 11, D.F.

THE GENERAL FOODS FUND FELLOWSHIPS

The three General Foods Fund, Inc., Fellowships, established to promote outstanding scholarship, are awarded to United States or Canadian citizens, engaged in senior undergraduate or graduate work in recognized educational or research institutions in the United States of America or Canada, in basic or applied chemistry, chemical engineering or related sciences, which may involve new physical or other procedures, directed to extending or improving knowledge in some phase of food conservation, food production or food processing, rather than primarily for research in the fields of nutrition, bacteriology or analytical chemistry.

Selection is based on the candidate's scholastic record at an institution of recognized standing and an approved plan of research in Food Technology. Acceptance by the Graduate School of the institution in which the applicant proposes to hold the Fellowship is also required.

Each Award ($4000) is for the full calendar year. Brief written reports (in duplicate) on progress may be required. A final detailed report, which may be in the form of a thesis or published paper, will be required (in duplicate) from each fellow.

How to apply. Apply in letter form, giving the customary essential personal and academic information. Include: name, nationality, sex, age, marital status; physician's statement with respect to the general health and physical condition; educational and experience background, college or university scholarship record; noteworthy accomplishments in research; purpose in applying for Fellowship Award.

Three letters of recommendation shall be forwarded separately to the Office of the Secretary of the Institute by Deans, Heads of Departments and/or Professors, who have supervised work of the applicants. These letters should present essential facts regarding the scholarship or record transcript thereof, character and personality, ability to cooperate and capacity for work and achievement of the applicants. Required also is a statement by the Head of the Department where the work will be done, endorsing the applicant and accepting for the school the responsibility connected with the acceptance of the Fellowship Award.

Mail your application and supporting papers prior to February 1, 1957 to:

Executive Secretary
Institute of Food Technologists
176 West Adams Street
Chicago 3, Illinois.

GERBER BABY FOODS SCHOLARSHIPS

AWARD: Six (6) undergraduate scholarships at $1,000.00 each, per year. The scholarships shall be for one school year of nine months. The student shall receive $100.00 per month for nine (9) months and the additional $100.00 shall be payable to the student at his own election any time during the school year. The awards are intended to cover the last two school years leading to a Bachelor's Degree in Food Technology, Food Engineering or Food Science. The awards shall be made to deserving and outstanding United States or Canadian citizens of at least second year standing in recognized educational institutions in the United States or Canada. Not more than two of these scholarships may be held in the same school at the same time, except under unusual circumstances.

The curriculum of the Department wherein the scholarship is to be held must be approved by the Donor. These scholarships will be continued for the second year only upon satisfactory performance by the student and recommendation of the Department head wherein the scholarship is held.

Applicants to qualify must have completed (1) two full years of college mathematics, (2) two full years of chemistry, (3) one full year of physics, (4) one full year of biological sciences, (5) at least one year of the humanities.

Candidates will be judged on over-all ability including scholarship, personality, extra curricular activities, social adjustment, character, etc.

PURPOSE: To encourage deserving and outstanding students to take undergraduate work leading to a Bachelor's Degree in Food Technology, Food Engineering or Food Science.

APPLICATIONS: Applications shall be in the form of a letter from the applicant, giving the following personal and academic information:

—Name, nationality, age, sex, marital status, and a physician's statement as to the general health and physical condition of applicant.

—A transcript of all college or university work already completed.

—A small photograph of the applicant.

—A list of extra curricular activities.

The Head of the Department wherein the student is to hold the scholarship must write a supporting letter direct to the Executive Secretary of the Institute of Food Technologists giving the following information:

A general appraisal of the applicant with particular reference to the detailed requirements listed above.
A statement that the student will be accepted in his Department.

Applications should be mailed, prior to February 1, 1957, to: Executive Secretary Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

FLORASYNTH FELLOWSHIP

The Florasynth Fellowship ($1000) granted annually, was established to honor and assist an outstanding individual engaged in advancing food technology. Candidates are nominated for this award by heads of college departments. Nominee must be a U. S. or Canadian citizen, under 35; a senior undergraduate, or one engaged in graduate work for an advanced degree, and enrolled in a recognized U. S. or Canadian institution conducting fundamental investigations for the adancement of food technology.

The Award is for the academic year. Brief written interim reports may be required. A final report, which

(Continued on page 16)

D&O CONDIMENT SEASONING CHART

For manufacturers supplying the vast "condiment" market, D&O has developed several specific lines of seasoning products. Each group possesses distinct qualities required by certain types of condiment products, making for an extensive and versatile coverage of the field. The chart below presents, briefly, these basic properties. For more complete information, order copies of the brochures prepared especially for this purpose.

PRODUCT	D&O SEASONING RECOMMENDED	PROPERTIES
PICKLES AND RELISHES	SPICEOLATE SPISORESIN SPISORAMA	*Spiceolate Seasonings* Water-soluble, spice flavors made from pure natural oils and oleoresins. Completely pure.
SALAD DRESSINGS	SPICEOLATE SPISORAMA SPECIALTY #M1002	*Spisoresin Seasonings* Oil-soluble seasonings made from special extractions of natural spices. Completely pure.
SAUCES AND CATSUP	SPICEOLATE SPISORAMA	*Spisorama Seasonings* Dry-soluble seasonings made from pure oils and oleoresins, prepared on a dry carrier for easy dispersability.

Available on request
- SPICEOLATE BROCHURE
- SPISORESIN-SPISORAMA BROCHURE
- SALAD DRESSING BROCHURE

Essentially for You

D&O ESTABLISHED 1798

OUR 158th YEAR OF SERVICE

DODGE & OLCOTT, INC.

180 Varick Street, New York 14, N. Y.

Sales Offices in Principal Cities

ESSENTIAL OILS · AROMATIC CHEMICALS · PERFUME BASES · FLAVOR BASES · DRY SOLUBLE SEASONINGS

(Continued from page 14)

can be in the form of a thesis or publication, is required. Awardees are selected by the Institute of Food Technologists Committee on Awards. Selection is based on outstanding qualities of character and personality, demonstrated scientific or engineering ability in the field of food technology, and a better than average scholastic record.

Procedure for applying. Nomination for this fellowship is made to the office of the Secretary of the Institute, in behalf of the proposed candidate, *by the Head of the Department* who supervises the undergraduate or graduate work of the candidate. Nomination must be in letter form, giving the customary essential personal and academic information with respect to the candidate. Educational and experience background, college or university scholarship record in transcript, noteworthy accomplishments in research, and reasons for proposing the candidate for the fellowship should be included.

Nominations must be received by the Executive Secretary, Institute of Food Technologists, 176 West Adams Street, Chicago 3, Illinois, prior to February 1, 1957.

THE SAMUEL CATE PRESCOTT FELLOWSHIP FOR THE ACADEMIC YEAR 1957-58

The Refrigeration Research Foundation, Inc. announces that the Fellowship Award honoring Dr. Samuel Cate Prescott, Emeritus Dean of Science, M.I.T., and the Foundation's Chairman of the Board is open for applications. As previously announced, the Fellowship carries with it a stipend of $2500 to be used for the academic expenses of "a graduate student in the U.S.A. or Canada in the field of food refrigeration or food technology, with special reference to the application of refrigeration to foods." In order to qualify the applicant must be a senior undergraduate with better than an average scholastic record or a graduate with a B.Sc. or equivalent, preferably with honors, from an institution of good standing.

Applicants should (1) prepare their applications in letter form giving name, nationality, sex, age, marital status, physician's statement of health, college scholarship record, noteworthy academic accomplishments, and job experience and (2) request a letter of recommendation from three faculty members who have supervised the scholastic or research work of the applicant *and* a statement by the Head of the Department where the applicant will do his work endorsing the applicant and accepting for the school the responsibility connected with the acceptance of the Award.

Address applications to:

MR. H. C. DIEHL
Secretary and Director
The Refrigeration Research Foundation
12 North Meade Avenue
Colorado Springs, Colorado

IFT ACTIONS AND REACTIONS . . .

Where Do Food Technologists Go and How Much Do They Make?[a]

Roy E. Morse
Department of Food Technology, Rutgers University, New Brunswick, New Jersey

THERE HAVE BEEN TRAINED technical men in and associated with the food industry for many decades now. The gradual transition of many branches of the food industry from an art to a science has further accelerated the entry of such people into the industry. In the early stages of this transition there were none specifically trained for the food industry and the industry took men where they could find them and proceeded to adapt them to the problems at hand.

In actuality, this transition rather traveled in cycles —as a quick chronological perusal of the literature readily shows. The early period was the Bacteriological Age and studies in the food field were heavily oriented in this direction, both at home and abroad. There was a good reason for this. The bacteriological problem was a serious one because human lives were at stake. After intense activity in this area the Chemical Age was ushered in, and attempts were and are still being made to understand the stuff of which foodstuffs are made. There naturally followed the application of the basic laws of chemistry to control and modify these changes, which, if left to run their course, would work to the nutritional and aesthetic detriment of mankind.

We are now, once again, in a transitional period. We are slipping from the Chemical Age into the Engineering Age. The food industry has been ever conscious of the handling of foodstuffs but has not always acted upon the knowledge gained. Meat packers suspended hogs from a conveyor chain to supply Henry Ford with an idea for revolutionizing the automotive industry. With the entry of the Engineering Age, came a notable advance in production methods—the reengineering of processing with the chemical and bacteriological aspects fully considered. It quickly became evident that there was need now for a person with training in several fields —engineering, chemistry, bacteriology—or, at least, one sufficiently cognizant of these fields to direct a group composed of personnel skilled in those specialisms.

(Continued on page 18)

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 12, 1956.

NEW LIFT... LONGER LIFE FOR YOUR PRODUCTS WITH FIRMENICH POWDERED FLAVORS

New and improved techniques of process drying, exclusively employed by Firmenich, yield powdered flavors that flow freely, are dust free, and give you the finest precision in flavoring your products. These important developments in quality flavoring will improve the taste appeal of your products . . . extend their shelf life . . . give them package-to-package uniformity that captures customer preference. Samples of Firmenich Powdered Flavors, with technical information on their practical application, on request.

FIRMENICH INCORPORATED

FIRMENICH & CIE
SUCCESSEURS DE
CHUIT NAEF & CIE.

250 WEST 18TH STREET, NEW YORK 11
FIRMENICH OF CANADA, LIMITED.
348 WALLACE AVENUE, TORONTO
CHICAGO OFFICE: 612 NORTH MICHIGAN AVENUE
LOS ANGELES, 908 SOUTH OXFORD AVENUE
GENEVA PARIS LONDON

(Continued from page 16)

The emergence of the Institute of Food Technologists in the late 30's and early 40's served as a rallying point for many "half-light" persons, who were a "coat-tail" fringe in the various established technical societies. The phenomenal growth of the Institute and the unbelievable proportion of its members who attend and actively participate in national meetings attest to the need and want of such an organization.

Dean Samuel C. Prescott . . . generated interest in food technology training and in IFT as a professional group.

With this founding group a neat little circle began to be described. The Institute attracted University attention, and from a handful of schools teaching Food Technology in the early Institute days the number grew until there are now at least 30 universities offering courses in the subject. We stand on another threshold, that of formalizing and bringing some semblance of order into current training procedures. There is keen interest in this subject, and the next few years should bring cautious but firm steps along this path.

Taking stock. It will be worthwhile at this juncture to stop and take stock of our field. Published literature directly related to the Food Technologist is difficult to come by, and so the data presented below has been culled from several publications *(1, 2, 3, 4)*. During the Institute Council Meeting (June, 1956) it was voted that, in view of the dearth of information available, a survey would be made of the Institute to obtain the facts. You will be able in the near future to contribute to this survey. I shall touch only lightly on the subject of where Food Technologists go (the first part of my discussion) and let the survey, which should be more precise than any information available to date, furnish the answer.

IFT President, 1956-1957, George Garnatz . . . heads organization that brings together food specialists of many fields.

Technically trained men can be found in every nook and cranny of the food industry and in all of its phases. Growing, harvesting, processing, distribution, nutrition and, most certainly, consumption—all are represented. The branches of the food industry in which technical men are productively at work include not only the food producing industries but also the suppliers of ingredients, of equipment, and of services. Consultants and disseminators of technical information are to be counted in the long list, but let us leave the breakdown to the Institute survey.

INDUSTRY PHILOSOPHY

What kind of an industry is the food industry for the technical man? The answer to this question must be a limited one but it is the best available to us in the literature at the moment. First, it should be realized that the food industry is a huge operation, in fact the largest in the nation in terms of annual sales dollars. In 1955 the sales volume of the industry was 67.5 billion dollars! This compares with the automotive industry at 17 billion, a poor second place. Keep these figures in mind in noting food research expenditures given below.

Table 1 is taken from the Harvard Business School Survey *(3)*. It shows that of the 4800 firms surveyed only 26.1% of the food companies responding maintained research organizations. By way of comparison, industrial chemicals stands first with research laboratories in 68.4% of the organizations responding. Last come firms dealing in lumber and wood products, which showed only 7.8% supporting research laboratories. This industry ranks 31st of those surveyed. The food industry ranked 23rd.

TABLE 1 [1]

Industries ranked by percentage of respondents maintaining research organizations: 1952

Industry	All firms	
	Percentage of respondents with research organizations	Rank [2]
Industrial chemicals	68.4%	1
Other professional, scientific, and controlling instruments	61.3	6
Other transportation equipment	37.0	16
Food and kindred products except beverages	26.1	23
Lumber and wood products	7.8	31

[1] "Spending for Industrial Research, 1951-1952." Page 22. Table II-8.
[2] The industry with the highest percentage in each column is assigned the rank of 1; the next highest the rank of 2; and so on. In those cases where more than one industry had the same percentage, the series of tied numbers is shown for each industry.

Table 2, from the same survey *(3)*, shows the median figures for research expenditures as a percentage of the sales dollar. The leather industry was lowest at 0.2% of sales dollar. The highest was the laboratory instrument business with one dollar in ten being returned to the business in the form of research investment. The average of all industries was 2.0% of the sales dollar. The food industry again shows up at the lower levels, with only 0.3% of the sales dollar spent on research.

TABLE 2 [1]

Total cost of research done within the company as a percentage of sales: 1951

Industry	All firms Median figures
Food and kindred products	0.3%
Drugs	3.5
Leather	0.2
Laboratory instruments	10.0
All firms	2.0

[1] "Spending for Industrial Research, 1951-1952." Page 32. Table III-1.

Table 3 from the Harvard Survey *(3)* reveals the cost per professional technical person. Here, contrary to the trend shown above, the food industry spends slightly above the average to keep the technical man at

(Continued on page 28 following technical papers)

THE Sealva STORY OF "Sealed-In" Flavors

Some years ago, van Ameringen-Haebler, Inc. developed and introduced SEALVA Flavors, the first truly hermetically "sealed-in" high quality dry flavors. This new technique in flavor-making was immediately recognized and enthusiastically accepted by the food industry.

Since those early days, continuing improvements in sealing agents and drying techniques plus the basic superiority in the quality of the natural or imitation flavors themselves, have combined to maintain SEALVA's place as the ultimate in fully protected quality flavors.

What can SEALVA do for your product?

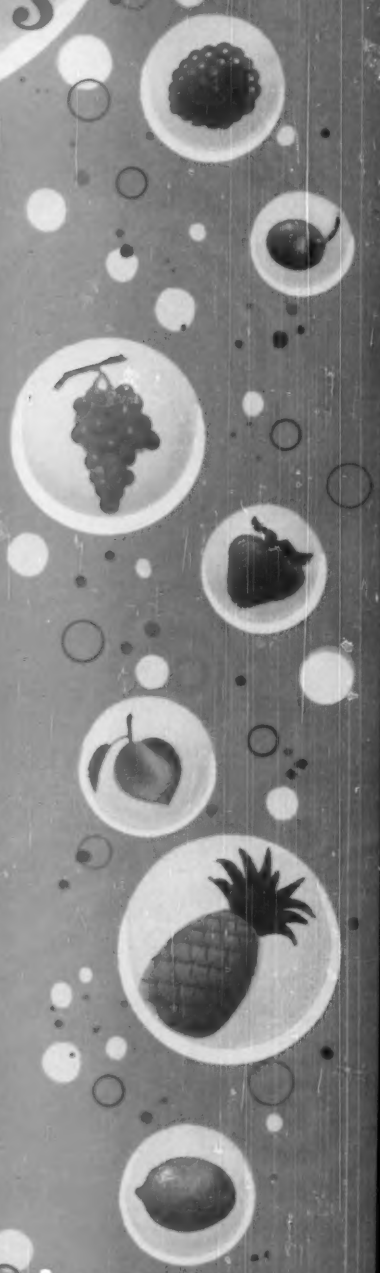
The adoption of SEALVA Flavors makes possible the use of absolute top quality flavor in dry mixes, because the finest of flavors are fully protected in their powdered form against the ravages of deterioration caused by evaporation, oxidation, extended shelf-life, and they are practically impervious to chemical reaction with other ingredients in a mix or compound.

Where can SEALVA Flavors be used to advantage?

SEALVA Flavors are ideal in any relatively dry, powdered, grained, or flaked mixture to insure inert flavor retention in such products as cake mixes, gelatin desserts, cereals, drink powders, pudding mixes, dairy mixes, ice cream mixes, candies (pressed wafer), pharmaceuticals, proprietaries, oil emulsions, etc.

For better flavor we ask you to investigate SEALVA Flavors before you make your final decision on this most important ingredient.

We are prepared to give you suggestions as to the methods of readily evaluating "sealed-in" flavors for your particular product and also will be happy to assist with technical recommendations for the application of SEALVA Flavors to improve your product. Literature and adequate samples are available.



Alva FLAVORS

VAN AMERINGEN-HAEBLER, INC.

521 WEST 57th STREET, NEW YORK 19, NEW YORK

SELECTED ABSTRACTS . . .

Compiled by H. A. Campbell

ANALYTICAL METHODS

A method for rapid analysis of very small gas samples.

LEWIS, H. E., AND LIPPOLD, O. C. J. (Univ. Coll., London). *J. Sci. Instr., 33* (7), 254-6 (1956).

An app. is described for the analysis of small samples of gas (0.1-0.001 ml.). A small bubble of the sample is injected into H_2O in a chamber formed by two horizontal parallel plates. This bubble assumes the shape of a disk, which can be measured, since the vol. is then proportional to its cross-sectional area. Convenient methods of optical measurement and recording are described. Analysis is made by the introduction into the chamber of suitable absorbents. Reference is made to some of the uses of this app.

A summary of methods for the detection of foreign fats in dairy products.

BHALERAO, V. R., AND KUMMEROW, F. A. (Univ. of Illinois, Urbana). *J. Dairy Sci., 39*, 956-64 (1956).

Tests or series of tests are discussed based on butyric acid, urea fractionation of butterfat, unsaponifiable matter, unsatd. fatty acids, iso-valeric acid content, hydroxamic color test, addn. of indicator substances to hydrogenated fats or studies of the glyceride compn. of butterfat. Determinations based on compn. of the unsaponifiable fraction or mixed fatty acid compn. are unreliable. However, butterfat has a characteristic glyceride structure not as yet duplicated by a fat other than butterfat.

Isolation and identification of nitrogenous components in meat.

ALEXANDER, J. C., AND ELVEHJEM, C. A. (Univ. of Wisconsin, Madison). *J. Agr. Food Chem., 4*, 708-11 (1956).

Ion exchange and paper chromatography procedures were used to identify the nitrogenous components in meat. A new system for gradient elution was employed to elute the amino acids from the column. Approximately 100% of the N contained in meat has been accounted for by 21 amino acids, NH_3, and other nitrogenous constituents such as vitamins, purines, creatine, carnitine and methylguanidine.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Crystalline xylanase.

INAOKA, M., AND SODA, H. (Faculty of Agriculture, Ehime Univ., Japan). *Nature, 178*, 202-3 (1956).

The cryst. enzyme catalyzes the hydrolysis of xylan to xylobiose, xylotriose and higher xylose-contg. oligosaccharides, but not to D-xylose. Crystallization was attained by $(NH_4)_2SO_4$ and acetone pptn. of the culture medium of a *Bacillus sp.* grown on a simple nutrient medium plus xylan.

Studies on the nitrogen metabolism of the ensilage process.

KEMBLE, A. R. (The King's Buildings, Univ. of Edinburgh, Engl.). *J. Sci. Food Agr., 7* (2), 125-30 (1956).

Both good and bad silages were studied. In the good silage the amts. of free amino-acids present were, in varying degrees, less than those calcd. from the extent of protein breakdown which had occurred. In the bad silage, a considerable excess of alanine above that which could have been formed by uniform proteolysis was present during the first three weeks of the fermentation, and, after, eight weeks, α-aminobutyric acid began to appear.

MICROBIOLOGY

Studies on the physiological activities of terramycin-resistant and terramycin-susceptible cultures of cheese-ripening strains of Streptococcus lactis.

ANGELOTTI, R. (Ohio State Univ., Columbus). *Dissertation Abstr., 15* (11), 1973 (1955).

Antibiotics in milk have an inhibitory effect upon the growth and acid production of dairy starter organisms, and milk contg. these substances is unfit for fermentative purposes. A process by which this problem may be eliminated is the development of antibiotic-resistant starters. The development of these resistant starters was shown to be feasible.

Salmonellosis. The role of food processing plants in the dissemination of Salmonella.

HARDY, A. V., GALTON, M. M. (Publ. Health Service, Atlanta, Georgia). *Am. J. Trop. Med. and Hyg., 4* (4), 725-30 (1955); *Biol. Abstr., 30* (9), No. 26714 (1956).

The role of com. food processing in distribution of *Salmonella* is obvious in the case of dehydrated eggs. Poultry as it is processed is heavily exposed to *Salmonella* contamination. Infections derived from insufficiently or improperly cooked fowl may be the result of this contamination rather than the spread of infection among living birds. *Salmonella* was found with unexpected frequency in pork products purchased on the open market. There was ample evidence that this was the combined result of rapid spread of infection among hogs a few hrs. or days before slaughter and wide dissemination of *Salmonella* within abattoirs. In the latter, the dehairing machine played an important role but elsewhere in abattoirs *Salmonella* could be cultured with surprising ease. Even a part of the infection of pets may be presumed due to feeding of com. prepd. dog food contg. *Salmonella*.

NUTRITION

The effect of intermittent consumption of calcium in rats.

LIU, C. H., ASHTON, G. C., AND CATRON, D. V. (Iowa Agricultural Expt. Sta., Ames). *J. Nutr., 59* (2), 267-71 (1956).

Four groups of 6 weanling rats each were fed equal amts. of a basal ration and supplementary Ca over a period of 6 wks. The basal ration contained 0.02% of Ca and 0.45% of P. Supplementary Ca was furnished in the form of carbonate and it was given to one group daily and to the other three groups at intervals of 2, 4 or 6 days. The intermittent feeding of equal amts. of $CaCO_3$ did not affect the gain in body wt. appreciably. The femurs of the rats which received a daily allowance of supplementary Ca had the greatest air-dry wt., ash wt., and total Ca and P content. The av. percentages of P in the femur ash bore no relation to the length of the interval of Ca feeding.

Response of rats to urea and related substances. The use of a spaced feeding technique.

FINLAYSON, J. S., AND BAUMANN, C. A. (Univ. of Wisconsin, Madison). *J. Nutr., 59* (2), 211-21 (1956).

Spaced feeding, the practice of feeding rats for only two hrs. per day, was found to increase the growth-depressing action of several nitrogenous compds. Spaced feeding increased the toxicity of L-leucine, diammonium citrate, $(NH_4)CO_3$ and 2,4-dinitrotoluene. Growth depressions by the NH_4-salts varied directly with blood urea. This regimen lessened the toxicity of 3'-methyl-4-dimethyl-aminoazobenzene and EtOH but had little effect on relative growth rates when biotin, vitamin B_{12} and folic acid were omitted from the diet or when glycine or antibiotics were added. The procedure shows promise in measuring the biol. value of small amts. of protein.

Flavor and aroma of birds fed purified and standard diets.

LEWIS, R. W., SANFORD, P. E., ERICSON, A. T., HARRISON, D. L., AND CLEGG, R. E. (Prairie View A & M Coll., Prairie View, Texas). *Poultry Sci., 35* (2), 251-3 (1956).

Taste panel evaluation of the light and dark meat showed that the flavor of the birds fed a standard diet was preferred to that of the birds fed a purified diet.

A relationship between protein level and energy level in chick rations.

SUNDE, M. L. (Univ. of Wisconsin, Madison). *Poultry Sci., 35* (2), 350-4 (1956).

Twenty and 28% protein diets were used. Each of these diets was supplemented with 0, 5, and 10% white grease. Energy levels of 655, 730, 771, 806, 845, and 932 productive cal. per lb. were used. The results showed that a high protein low energy diet causes a reduction in the growth rate and a reduced efficiency of feed utilization. Raising the energy level

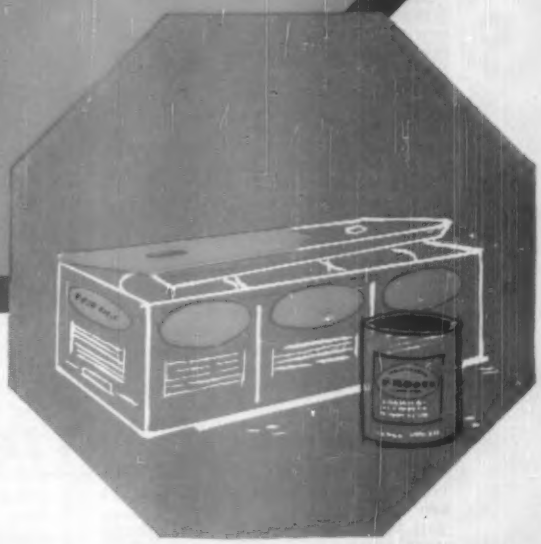
(Continued on page 22)

NOW

YOU CAN FIND OUT WHAT

FRODEX

CAN DO FOR YOU



FRODEX has many wonderful properties, such as building food solids where desired, improving texture, flavor, color, stabilizing moisture and extending shelf life. FRODEX is widely used in luncheon meats, food mixes, frozen foods, ice cream, baked goods, catsup and soup mixes, to mention a few. You too can find benefits from this versatile product in one of its many forms.

Our research department, with its wide experience in working with FRODEX in all types of food products, is available to assist you without obligation. For your convenience, we will send on request a handy sample testing kit containing FRODEX 24 malto-dextrin, regular (powdered) FRODEX corn syrup solids and granular FRODEX corn syrup solids. *Simply fill in the attached coupon and mail today.*

AMERICAN MAIZE PRODUCTS COMPANY
250 PARK AVENUE • NEW YORK 17, N. Y.

AMERICAN MAIZE PRODUCTS COMPANY • 250 PARK AVE. N. Y. 17, N. Y.

Please send free sample FRODEX kit.

Name.....

Firm Name.....

Address.....

ATLANTA · BOSTON · BROOKLYN · BUFFALO · CHICAGO · DENVER · FORT WORTH · GRAND RAPIDS · LOS ANGELES
MEMPHIS · PHILADELPHIA · PITTSBURGH · PORTLAND · ST. LOUIS · ST. PAUL · SAN FRANCISCO · SEATTLE

Chemists! Technologists!

Test Your Know-how

How many uses for

Sta-Sol®

Lecithin Concentrate can you name?

Here are just a few applications for dozens of products.

Whether as an emulsifier, antioxidant, penetrant, or wetting agent Staley's Sta-Sol Lecithin concentrate has already proved its versatility in dozens of applications in a variety of products. And new uses are continuously being uncovered. A look at the partial listing below will give an idea of Sta-Sol's wide utility range.

Leather Processing—penetrating and softening agent.
Paints—retards settling and hardening of pigments—prevents "flooding" and streaking.
Pharmaceuticals—antioxidant for Vitamin A.
Bakery Goods—emulsifier—antioxidant—softens texture—reduces stickiness of doughs—prolongs shelf life—improves fat distribution.
Candy & Chocolate Coatings—reduces viscosity, increases coating capacity, less stickiness, retains moisture, lowers surface tension, improves texture and appearance.
Printing Inks—reduces grinding time, promotes better wetting and dispersion of pigments.
Shaving Creams—increases wetting power of lather, makes beard softer, gives smoother more "painless" shave.
Skin Lotions, Cosmetics, Beauty Soaps—softens and soothes skin, reduces irritation, increases cleansing power, stabilizes and improves lather.
Gravies-Sauces—prevents fat separation.
Peanut Butter—antioxidant—stabilizes flavor.

Can you add other uses to this list?
New product applications for Sta-Sol are being added all the time. Can you think of other uses? Perhaps your products should be added to this list. If you're in need of a more efficient, more economical emulsifier antioxidant, penetrant or wetting agent—get all the facts about Sta-Sol. See your Staley representative or write today for complete information. Learn how Sta-Sol can help you improve the quality of your products.

A. E. Staley Mfg. Co.
Decatur, Illinois

Staley's

(Continued from page 20)

of this diet by the addn. of fat increased the wt. of the chicks at both four wks. and ten wks. and improved the feed utilization.

Food intake and utilization of lysine deficient protein by the chick in relation to the digestible energy concentration of the diet.

WILLIAMS, M. A., AND GRAU, C. H. (Univ. of California, Berkeley). *J. Nutr., 59* (2), 243-54 (1956).

Semipurified diets contg. 15% sesame protein and various levels of lysine were fed *ad libitum* to two-wk. old chicks for a period of 18 days. The substitution of 12% or more of cellu flour (wood-pulp cellulose) for an equal wt. of glucose resulted in improved growth with all of the diets deficient in lysine. The improved growth was most readily attributed to the increased feed and lysine intake in response to the decrease in the digestible energy concn. of the diets caused by the substitution of cellu flour for glucose.

Feather meal in chick nutrition.

LILLIE, R. J., SIZEMORE, J. R., AND DENTON, C. A. (U.S.D.A., Beltsville, Md.). *Poultry Sci., 35* (2), 316-18 (1956).

Studies were undertaken to evaluate the nutritional significance of feather meal in broiler diets. Using New Hampshire broilers fed an all-vegetable protein diet amply fortified with all known required nutrients, including an antibiotic, arsenical, methionine and folic acid, feather meal was found to replace fish meal in eliciting a growth response. This growth stimulation could not be attributed to the protein of feather meal, but possibly to the presence of an unidentified growth factor.

Degossypolized cottonseed meal as a substitute for soybean oil meal in a turkey growing mash.

WEST, J. W. (Mississippi Agricultural Expt. Sta., State Coll.). *Poultry Sci., 35* (2), 304-7 (1956).

Degossypolized solvent cottonseed meal was used to replace 0, 20, 40, 60, 80 and 100% of the soybean oil meal in a practical-type turkey growing mash during the period from 8 to 28 wks. When the turkeys were ready for market, it was evident that degossypolized cottonseed meal could be used to replace all of the soybean oil meal both in the turkey starting ration and in the turkey growing-finishing mash without adverse effect upon growth, feed efficiency, uniformity and livability. Combinations of degossypolized cottonseed meal and soybean oil meal improved growth of the poults slightly but rather consistently over that obtained by either meal fed singly.

PHYSIOLOGY AND MEDICINE

Increased intestinal absorption of glucose in three forms of obesity in the mouse.

MAYER, J., AND YANNONI, C. Z. (Harvard Sch. of Public Health, Boston, Mass.). *Am. J. Physiol., 185* (1), 49-53 (1956).

In three types of obesity in the mouse, obese-hyperglycemic syndrome, gold-thioglucose obesity and hypothalamic obesity, there is observed an increase in intestinal absorption of glucose when the dose of glucose administered is sufficient. This phenomenon appears to be an adaptative result of prolonged hyperphagia.

The interrelationship between cerebral and coronary atherosclerosis.

YOUNG, W., GOFMAN, J. W., MALAMUD, N., SIMON, A., AND WATERS, E. S. G. (Univ. California, Berkeley). *Geriatrics, 11,* 413-18 (1956).

Quantitative measurement reveals that the degree of atherosclerosis of the coronary arteries is positively correlated with the degree of atherosclerosis of the major supply arteries to the brain. This interrelationship suggests that some metabolic factor, such as lipoprotein level is important for brain atherosclerosis as well as for coronary atherosclerosis.

Cholesterol vehicle in experimental atherosclerosis. II. Influence of unsaturation.

KRITCHEVSKY, D., MOYER, A. W., TESAR, W. C., MCCANDLESS, R. F. J., LOGAN, J. B., BROWN, R. A., AND ENGLERT, M. E. (Am. Cyanamid Co., Pearl River, N. Y.). *Am. J. Physiol., 185* (2), 279-80 (1956).

Short-term expts. showed that the severity of atheromata in cholesterol-fed rabbits appears to vary inversely with the I no. of the fat used as vehicle for the sterol. The serum cholesterol levels increase with increasing I no. and the serum lipoprotein levels vary, depending on the class of lipoproteins being studied.

Folic acid and vitamin B_{12} in medical practice.

UNGLAUB, W. G., AND GOLDSMITH, G. A. (Tulane Univ. Sch. of Med., New Orleans, La.). *J. Am. Med. Assoc., 161* (7), 623-7 (1956).

Paper prepd. at the request of the Am. Med. Assoc. Council on Foods and Nutrition, reviews the nature and metabolic functions of folic acid and vitamin B_{12}. Indications are that the use of the latter vitamin is of value in the treatment of pernicious anemia but that the use of folic acid should be avoided.

Metabolic effects of fat emulsions administered intravenously to human subjects.

BENTLEY, W. B. A., AND VAN ITALLIE, T. B. (1039 Chase Parkway, Waterbury, Conn.). *J. Lab. Clin. Med., 48,* 184-93 (1956).

Studies on the metabolic effect of 15% fat emulsions, administered intravenously to four healthy volunteer subjects maintained on const. diets inadequate in cals. and adequate in protein are described. The negative N and K balances produced by caloric privation were significantly decreased when intravenous fat emulsions providing approx. 1,200 to 1,400 cals. per day were administered as caloric supplements. The K balances responded more dramatically to intravenous fat administration than did the N balances. These studies constitute further evidence that suitably prepd. intravenous fat emulsions administered to human subjects are

(Continued on page 25)

For fresh-from-the-field **FLAVOR!**

GIVAUDAN IMITATION STRAWBERRY

Nothing compares with the flavor of fresh wild strawberries. And nothing has duplicated that flavor as closely as Givaudan's Imitation Strawberry!

It is economical—highly concentrated yet easy to use on a controlled level. And it's stable—ideal for use in milk-containing products as well as in confections, summer drink powders and other preparations. Available in liquid or crystal form. May we send you samples and more complete information?

Givaudan Flavors Inc.

330 West 42nd Street
New York 36, N. Y.

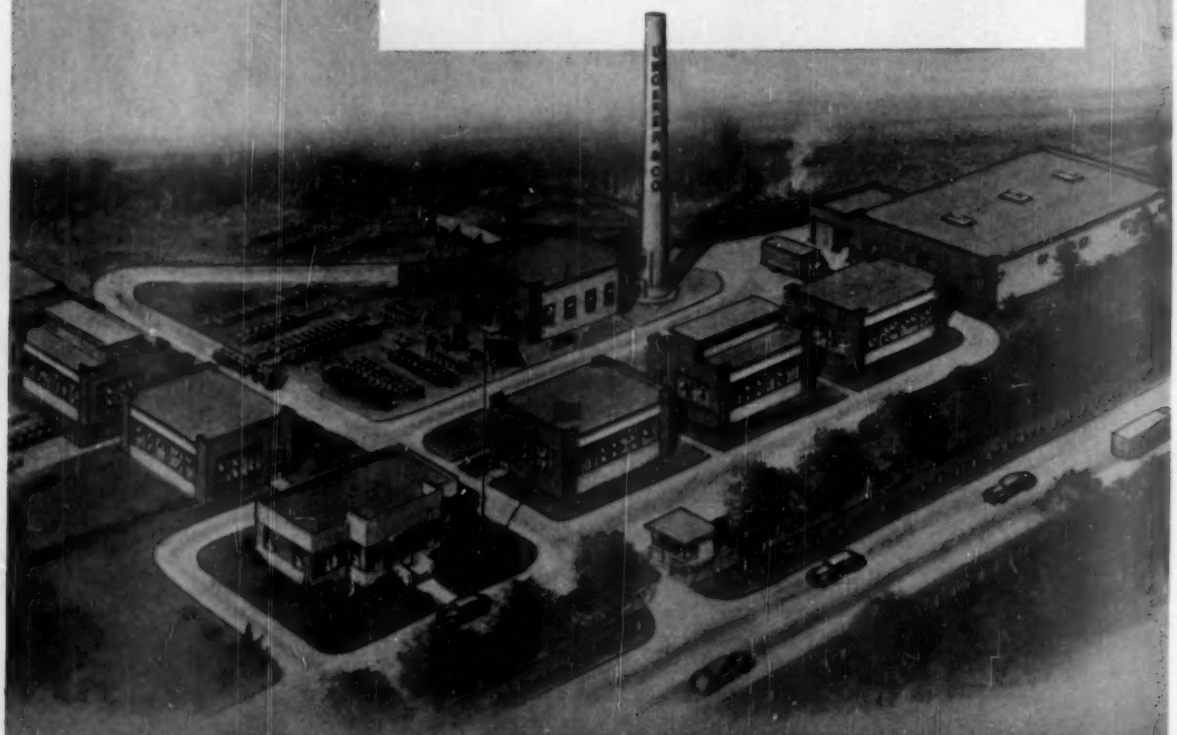
You're sure to be in

GOOD TASTE

when you specify

UNGERER

TRUE FRUIT & IMITATION FLAVORS
UNIFORM • CONCENTRATED • STABLE



Plant and Laboratories, Totowa, New Jersey

Ungerer & Co.

161 Avenue of the Americas, New York 13, N. Y.

CHICAGO • BOSTON • PHILADELPHIA • ST. LOUIS • LOS ANGELES • ATLANTA

Quality Retention in Baby Foods Processed By High Temperature-Short Time Methods[a]

G. E. Livingston, W. B. Esselen, E. Feliciotti,[b] D. E. Westcott,[c] and M. P. Baldauf[d]

Department of Food Technology, University of Massachusetts, Amherst, Massachusetts

(Manuscript received June 13, 1956)

IT IS GENERALLY RECOGNIZED that the flavor and appearance of many commercially packed products could be improved by reducing the severity of the required thermal sterilization process. One means whereby such a reduction can be achieved, with favorable results, is through the use of agitating retorts which produce more rapid rates of heat transfer than could be obtained in still retorts. Another, and still more beneficial means, is the use of various "high temperature-short time" methods (HT-ST).

Two of the HT-ST canning methods developed in recent years are the Martin Aseptic Canning System invented by Dr. W. McK. Martin *(4)* and the Smith-Ball Pressure Canning Process developed by Drs. H. L. Smith, Jr. and C. O. Ball *(5)*. The Martin process inolves the sterilization of liquid or semi-solid products at high temperatures in a tubular heat exchanger, followed by filling under aseptic conditions into presterilized containers. In the Smith-Ball process, the product is also sterilized at temperatures more elevated than those used in conventional retorting. Filling and sealing operations are not aseptic, but are carried out in a chamber with an internal pressure of approximately 15 lbs. Under these conditions, the product, preheated in a heat exchanger, can be filled into cans or jars at temperatures comparable to those used in retorting. Containers and lids are steam sterilized prior to their arrival at the filling station.

Through the efforts of the Glass Container Manufacturers Institute and with the collaboration of various other groups, a study was initiated in 1952 to explore the possibility of applying HT-ST methods to the processing of strained baby foods. Data presented in this paper were obtained on experimental packs of baby foods, processed by the Martin Aseptic System or the Smith-Ball process, and submitted to this laboratory for storage and examination.

EXPERIMENTAL

Preparation, and processing of baby food samples. *Martin Aseptic Canning System:* Samples were packed by the James Dole Engineering Co., Redwood City, California, in collaboration with the Beech Nut Packing Co., the Gerber Products Co., the National Canners Association, and the Glass Container Manufacturers Institute. Filling and sterilization of HT-ST samples were carried out using a pilot plant Martin Aseptic Canning System for glass containers. Control samples prepared from the same product lots were packed with conventional commercial or pilot plant canning squipment. Standard 5-oz. baby food jars and closures were used in all cases.

Smith-Ball Pressure Canning Process: Products were prepared at the Gerber Product Co., Fremont, Michigan, and control samples were packed there with commercial equipment. A portion of each product was trucked cold in gallon jugs to the LaChoy Food Products Co. plant, Archbold, Ohio, for packing by the Smith-Ball Process. In the latter, products were sterilized by passage through a Votator tubular heat exchanger, and filled into steam-sterilized 5-oz. baby food jars at 247°-250° F. (119°-121.1° C.). Temperature of jars at the time of filling was also approximately 250° F. (121.1° C.). Immediately after capping, jars were sealed with a steam vacuum hand capper with a steam pressure of 2-6 lbs. Upon sealing, the jars were inverted and held in that position for at least 5 minutes, allowing the hot product to contact the cap. At the end of this period, jars were dropped into tubs of hot water at 170°-180° F. (76.5°-82.2° C.) which was gradually cooled to 70°-80° F. (21.1°-26.7° C.)

Processing data for both packs are summarized in Table 1.

TABLE 1

Summary of processing data for samples analyzed

Product	Process	HT-ST process		Conventional process	
		Time (sec.)	Temp. (° F.)	Time (min.)	Temp. (° F.)
Beets	Martin	....	276	35	252
Carrots (Chantenay)	Martin	24	276	50	240
Carrots (Emperator)	Martin	24	275	35	252
Carrots	Smith-Ball	....	260-263	50	240
Green Beans	Martin	24	276	45	240
Peas	Martin	24	284	50	245
Spinach	Martin	24	278	45	245
Spinach	Smith-Ball	....	260	60	240

Laboratory evaluation of samples. Not all of the following tests and analyses were carried out on all of the sample lots, but the methods cited were used where so indicated by the data summarized in Tables 2 to 4.

1. Physical measurements
   a. *Vacuum* was measured using an F.I.R.A. gauge, which compensates for errors due to variations in headspace volume.[e]
   b. *Viscosity* was measured on samples at 40° F. (4.5° C.) using a Brookfield Viscometer at 20 r.p.m. with a No. 6 spindle.[f] Measurement was taken after 10 seconds of rotation.
   c. *Color* measurements were made on both the pureed samples and decolorized (by acetone extraction of the pigments) tissue of the samples *(6)*. *Reflectance* measurements were made using one of 3 instruments: a Photovolt Model 610 Reflection Meter,[g] a Beckman DU Spectrophotometer[h] equipped with a reflection attachment and an American Optical Rapid Scanning Spectrophotometer[i] equipped with a reflection attachment. Color standards used were: Munsell paper standards and a calibrated white enamel plate for the Photovolt instrument, a National Bureau of Standards calibrated Vitrolite glass plate for the Beckman and a white carrara glass standard for the American Optical Spectrophotometer. The following filters and Munsell paper standards were used with the Photovolt

[a] Contribution No. 1050 Massachusetts Agricultural Experiment Station. Presented at the 16th Annual Meeting of IFT at St. Louis, June 11, 1956.

[b] Present Address: Hazel-Atlas Co., Washington, Pa.

[c] Present Address: Cryovac Co., Cambridge, Mass.

[d] Present Address: Ohio Agricultural Experiment Station, Wooster, Ohio.

[e] Made by Budenberg Gauge Co., Ltd., Broadheath, Eng.

[f] Made by the Brookfield Engineering Laboratories, Stoughton, Mass.

[g] Photovolt Corp., 95 Madison Ave., New York, N. Y.

[h] Beckman Instruments Inc., South Pasadena, Calif.

[i] American Optical Co., Instrument Div., Buffalo, N. Y.

Reflection Meter: beets—red, 5 R 5/10; carrots—tri-amber, 5 Y 8/9, green beans and spinach—trigreen, 7.5 Y 5/6 and peas—trigreen, 5 Y 8/8.

2. Chemical determinations
   a. *pH* was measured with a Beckman [a] model G pH meter.
   b. *Ascorbic acid* was determined colorimetrically by the method of Loeffler and Ponting *(3)*.
   c. *Carotene* was determined by the official A.O.A.C. *(1)* method.
   d. *Thiamine* was determined by the official A.O.A.C. *(1)* method.

3. Organoleptic evaluation

Triangular difference-preference tests were employed using subdued illumination to preclude the possibility of distinguishing between samples on a visual basis. Taste panel members were selected from the staff of the Food Technology Department of this University. Tests were carried out in duplicate and recorded as valid only when reproducible results were obtained.

RESULTS AND DISCUSSION

The products studied were:

Martin process		Smith-Ball process
beets	spinach	carrots
carrots	chicken soup	spinach
green beans	vegetable and beef	
peas	vegetable and bacon	
	vegetable and lamb	

Varieties of vegetables used were generally unknown, except in the case of the carrots packed by the Martin process, where Red Core Chantenay and Emperator varieties were used. Unfortunately, samples of all products handled by the Martin process were not shipped directly to Amherst upon packing, so that in several instances no data on the initial differences in physical and chemical properties of the products could be obtained.

For this reason, as well as for the sake of brevity, only the most pertinent data on all products are presented in a summary form in Tables *2* through 4.

Effect of HT-ST sterilization on physical characteristics. It appears obvious that of the physical characteristics measured in this study, color was the only one significantly affected by the difference in processing treatment. Color differences between samples processed by the HT-ST methods and those conventionally handled were quite obvious in most instances. Strained peas comprised the only product in which the level of visual difference was almost marginal. In the case of all the other vegetable products, however, the HT-ST processed samples possessed a brighter, more appealing color, which was, to a large extent, retained in storage. As shown in Table *2*, the brighter color resulted mostly, as might be expected, in higher levels of diffuse reflectance. This, however, did not hold true for beets, green beans, and spinach—whose natural color is generally made lighter in the course of conventional retorting. The color of the HT-ST processed samples of these products was therefore darker than that of the controls, and more nearly like the color of the freshly cooked vegetables.

The remarkable effect of HT-ST processing on the color retention of strained vegetables is further illustated by the storage data in Table *2* as well as Figures 1 through *7*. In the case of the strained carrots from the Smith-Ball pack, Figure 5, it is readily seen that even after 3 years of storage, a significant color difference exists between the HT-ST processed and the conventional samples. Spectrophotometric data on these samples, Figure 1, reveals that HT-ST processed samples actually underwent partial bleaching in storage, while the control sample underwent a reduction in reflectance (darkening), in the yellow-orange region of the spectrum. The net result is even a greater color difference between HT-ST processed carrots and controls after 3 years' storage than immediately after canning. Perhaps a clue to the cause of this phenomenon is offered by tissue reflectance measurements made. It has been previously reported *(5)* that the color change accom-

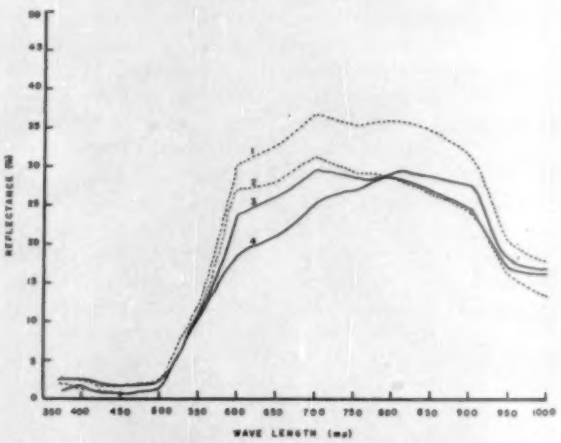


Figure 1. Spectral Reflectance of Strained Carrots Packed by Smith-Ball Process and Control Samples Conventionally Retorted. (1—HT-ST after 3 years' storage; 2—HT-ST before storage; 3—Control, before storage; 4—Control after 3 years' storage.)

TABLE 2

Changes in the reflectance of strained vegetables stored for 9-10 months

Product	Months storage	Reflectance (%)					
		HT-ST process			Conventional process		
		Before storage	After storage at		Before storage	After storage at	
			68°-80° F.	95°-100° F.		70° F.	95°-100° F.
Beets	9	17.3	17.0	20.0	25.5	27.0	29.0
Carrots (Chantenay)	9	40.0	38.0	39.5	37.8	35.5	36.5
Carrots (Emperator)	9	40.3	32.0	36.0	37.8	30.0	24.0
Carrots (Smith-Ball)	9	39.0	38.0	36.0	37.5	35.0	28.0
Green Beans	9	64.0	66.0	62.0	73.5	71.0	70.0
Peas	10	43.0	45.0	41.0	41.0	41.0	42.0
Spinach (Martin)	9	36.0	36.0	33.0	42.5	38.0	36.0
Spinach (Smith-Ball)	9	35.8	30.0	31.0	39.0	36.0	34.0

panying nonenzymatic storage discoloration of pureed green beans is due, at least in part, to the darkening of the plant tissue itself, rather than to any darkening in the soluble fraction or pigment degradation. Though not previously reported, similar observations were made by Brody *(2)* on a wide variety of fruit and vegetable products whose plant tissue could be freed from pigments by simple solvent extraction. It was noted in the present study that the tissue from the HT-ST processed Smith-Ball carrots was appreciably lighter (C. I. E. Y = 34.5%) than that isolated from the control (Y = 25.0%) immediately upon storage. When similar measurements were carried out on samples stored for 3 years at room temperature, the reflectance of the HT-ST tissue was 18% as compared to 9.5% for the tissue from control samples. (It is pertinent to note that all tissue reflectance measurements were carried out on acetone-moistened tissue, not on the dried tissue shown in Figure 8).

Color changes affecting strained spinach from the Smith-Ball experiment over a 3-year storage period were less pronounced (Figure 6). Figure 2 shows

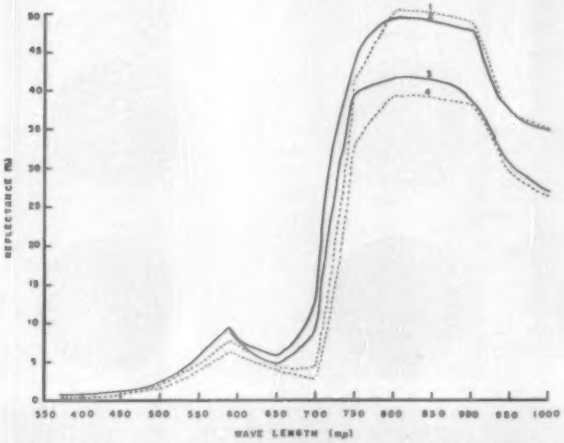


Figure 2. Spectral Reflectance of Strained Spinach by Smith-Ball Process and Control Samples Conventionally Retorted. (1—HT-ST after 3 years' storage; 2—Control, after 3 years' storage; 3—Control, before storage; 4—HT-ST before storage.)

little change in reflectance of the spinach samples in the green region of the spectrum. Both the HT-ST and the control purees, however, showed increased reflectance in the orange-red region storage.

Strained beets and peas from a more recent experimental pack processed by the Martin system are shown with their controls in Figure 7. Spectral reflectance curves for these samples appear in Figures 3 and 4.

Effect of HT-ST sterilization on chemical characteristics. The depression in pH which accompanies conventional canning treatments is a matter of general knowledge. It is therefore interesting that HT-ST sterilized products retained a higher pH than retorted controls. For example, Smith-Ball processed carrots and spinach showed initial pH values of 5.81 and 5.88, respectively, whereas the retorted carrots and spinach purees showed pH values of 5.29 and 5.48. Similar differences were found to apply to the other vegetable

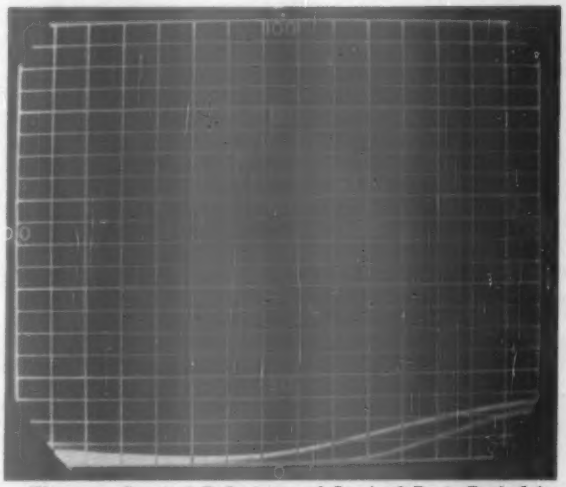


Figure 3. Spectral Reflectance of Strained Beets Packed by the Martin Process and Conventionally Retorted Control Samples, Stored for 9 Months at 70°-80° F. (Upper curve; control sample; lower curve; HT-ST samples.)

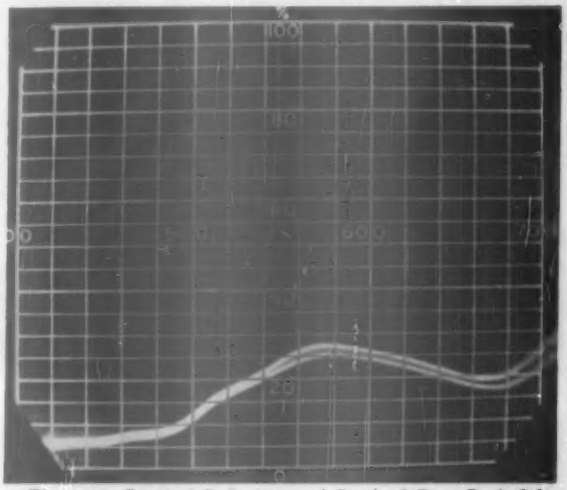


Figure 4. Spectral Reflectance of Strained Peas Packed by the Martin Process and Conventionally Retorted Control Samples, Stored for 9 Months at 70°-80° F. (Upper curve; control sample; lower curve; HT-ST sample.)

products examined. Further pH decreases were found to be associated with increasing storage temperatures as well as length of storage. After 12 months' storage the pH of the Smith-Ball carrots and spinach samples had declined to 4.98 and 5.28, respectively, as compared to 5.03 and 5.24 for the conventional controls. Thus, notwithstanding the initial differences associated with processing treatment, pH levels of HT-ST and control samples tended to reach similar values upon storage.

Ascorbic acid and carotene determinations carried out on carrot samples from the Martin and Smith-Ball packs showed no significant differences associated with processing treatment (Table 3). Apparent discrepancies in data on both carotene and ascorbic acid content are probably attributable to experimental errors.

Thiamine on the other hand, being a heat-labile vitamin, was found to be markedly affected by the differ-

ences in thermal treatments imparted by the HT-ST and conventional methods. Table 3, which summarizes data obtained on 9 products, clearly indicates the significantly greater thiamine retention in HT-ST processed samples over controls. In all instances, an appreciably greater thiamine content was also retained by the HT-ST samples in storage, even over periods of 9-10 months at 95°-100° F.

No significant differences attributable to processing were found in vacuum and viscosity measurements.

Effect of HT-ST sterilization on organoleptic characteristics. It appeared reasonable to expect that the striking color differences generally existing between HT-ST and conventional samples constituted but one of the organoleptic properties of the products which were affected by the mode of processing. However, triangular difference-preference tests using a small panel of judges (6-12 members) appeared to indicate (a) that differences in odor and taste were definitely marginal and (b) among judges able to correctly select the odd sample in two trials, preference was divided for most products. There was no indication that storage materially increased flavor differences between samples or greatly affected preference pattern. Descriptive comments of some of the judges on samples under examination frequently included the terms "raw" or "fresh," particularly in reference to HT-ST treated samples of strained beets, peas, and green beans.

Figure 5. Strained Carrots Packed by the Smith-Ball Process and Conventionally Retorted Controls Showing the Effect of One Year's Storage.

Figure 6. Strained Carrots and Spinach Packed by the Smith-Ball Process and Conventionally Retorted Controls Showing the Effect of Three Years' Storage at 70°-80° F.

Figure 7. Strained Beets and Peas Packed by the Martin Process and Conventionally Retorted Controls Showing the Effect of One Year's Storage at 70°-80° F.

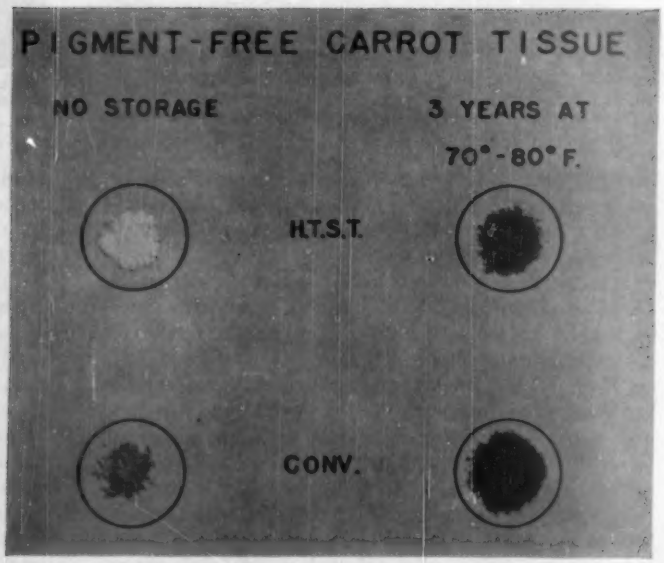


Figure 8. Pigment-Free Tissue Isolated from Strained Carrots Showing the Effect of Thermal Processing and Storage for Three Years at 70°-80° F.

TABLE 3

Ascorbic acid, carotene and thiamine content of strained vegetables and soups stored 6-10 months

Product	Months storage	Process					
		HT-ST			Conventional		
		Before storage	After storage at		Before storage	After storage at	
			70°-80° F.	95°-100° F.		70°-80° F.	95°-100° F.
Ascorbic Acid (mg. %)							
Beets	9	....	0.8	2.6	....	3.7	4.4
Carrots (Chantenay)	9	4.4	2.3	1.8	4.4	3.2	2.9
Carrots (Emperator)	9	5.5	3.9	1.6	5.2	3.9	4.0
Carrots (Smith-Ball)	9	0	0	0	0	0	0
Green Beans	9	1.3	1.6	1.2	2.4	1.6	3.1
Peas	10	11.3	13.0	1.8	10.7	13.0	12.0
Spinach (Martin)	9	12.9	13.4	10.5	12.4	12.6	9.5
Spinach (Smith-Ball)	9	3.2	5.8	5.3	3.2	3.7	1.3
Carotene (mg. %)							
Carrots (Chantenay)	9	9.2	11.4	12.1	10.0	13.0	13.2
Carrots (Emperator)	9	10.0	10.7	8.1	7.0	10.2	7.7
Carrots (Smith-Ball)	9	10.4	9.3	9.2	10.3	8.2	9.5
Thiamine (μg.)							
Beets	9	6.0	Trace	Trace	1.7	Trace	Trace
Carrots (Chantenay)	9	25.5	13.6	12.2	23.9	9.3	6.7
Carrots (Emperator)	9	16.4	14.5	13.3	10.4	7.0	5.8
Carrots (Smith-Ball)	6	15.0	15.3	11.0	10.4	9.3	8.0
Green Beans	9	69.4	31.1	22.8	54.6	12.3	10.7
Peas	10	....	81.8	61.8	....	39.8	28.2
Spinach (Martin)	9	....	12.3	8.4	12.7	3.6	2.8
Spinach (Smith-Ball)	6	15.0	12.2	8.3	7.5	6.5	1.7
Chicken Soup	6	....	37.6	34.0	....	27.2	25.2
Vegetable and Beef	6	....	19.5	13.8	....	12.1	....
Vegetable and Bacon	6	....	21.8	16.8	....	15.3	12.8
Vegetable and Lamb	6	....	27.4	21.4	....	10.5	9.0

TABLE 4

Result of triangular differences-preference taste tests on HT-ST and conventionally processed strained vegetables before and after storage for 6-12 months at room temperature (68° F.-80° F.)

Products	Months storage	Difference test				Preference test				
		Before storage		After storage		Before storage			After storage	
		Right (%)	Wrong (%)	Right (%)	Wrong (%)	HT-ST (%)	Conv. (%)	No. Prefer. (%)	HT-ST (%)	Conv. (%)
Beets[1]	9	89	11	100	0	38	50	12	50	50
Carrots (Chantenay)	9	67	33	83	17	75	25	0	60	40
Carrots (Emperator)	9	67	33	67	33	100	0	0	75	25
Carrots (Smith-Ball)	6	25	75	67	33	33	33	33	50	50
Carrots (Smith-Ball)	12	25	75	67	33	33	33	33	100	0
Green Beans	9	44	56	50	50	25	0	75	67	33
Peas	9	38	62	33	17	33	0	67	40	60
Spinach (Martin)	9	56	44	33	67	60	40	0	100	0
Spinach (Smith-Ball)	6	8	92	40	60	100	0	0	50	50
Spinach (Smith-Ball)	12	8	92	50	50	100	0	0	33	67

[1] Obvious difference in consistency.

SUMMARY AND CONCLUSIONS

Samples of strained foods processed by the Martin Aseptic Process and by the Smith-Ball method were examined after packing and storage and compared against conventionally retorted controls. Quality evaluation included measurement of vacuum, pH, viscosity and color, determination of vitamin B_1, C, and carotene content, and triangular taste panel appraisal. In general, products processed by high-temperature-short time methods showed better color and thiamine retention, and initially higher pH values than control samples. Color and thiamine advantages were retained over extended storage periods. Flavor differences were largely marginal for most products, although in some instances, HT-ST vegetable samples were described as having a "raw" or "fresh" taste.

Acknowledgments

The authors are deeply indebted to the following organizations whose participation in this study made it possible: The Beech Nut Packing Co., The Dole Engineering Co., The Gerber Products Co., The Glass Container Manufacturers Institute, The LaChoy Food Products Co., The National Canners Association and the Owens-Illinois Glass Co. The assistance of Dr. H. D. Brody and Mr. A. Naik-Kurade in various phases of the laboratory examination is also appreciated.

LITERATURE CITED

1. Association of Official Agricultural Chemists. *Methods of Analysis.* 7th Ed. 910 pp. (1950).
2. Brody, H. D. Storage Changes in Pureed Foods. (M.S. Thesis, University of Massachusetts, 1953).
3. Loeffler, H. J., and Ponting, J. D. Ascorbic Acid-rapid determination in fresh, frozen or dehydrated fruits and vegetables. *Ind. Eng. Chem., Anal. Ed.*, **14**, 846-849 (1942).
4. Martin, W. M. Flash process, aseptic fill are used in new canning unit. *Food Inds.*, **20**, 832 (1948).
5. Smith, H. L., Jr., and Ball, C. O. Smith-Ball Pressure Canning Process. Paper presented at XIIIth Annual Meeting of the IFT, Boston, Mass., June 24, 1953.
6. Westcott, D. E., Livingston, G. E., Esselen, W. B., and Fellers, C. R. Nonenzymatic discoloration of green bean puree. *Food Research*, **20**, 149-150 (1955).

Deterioration of Cooked Southern Oysters[a, b, c]

Elizabeth Ann Gardner and Betty M. Watts
The Florida State University, Tallahassee, Florida

(Manuscript received June 23, 1956)

ALMOST ALL INVESTIGATIONS of oyster spoilage reported in the literature have been made with fresh or frozen raw oysters in which the spoilage is of a fermentative type, characterized by a sour odor, or putrefactive in nature. Baldwin, Puncochar, and Pottinger *(1)* measured the changes in pH, water soluble nitrogen, alcohol soluble nitrogen, and total titratable acids during storage of raw eastern oysters. From the standpoint of ease, rapidity, and reliability of results, pH values seemed to them to be the most promising of these measurements as an indicator of oyster freshness. They described oysters at a pH of 6.2 to 5.9 as being in good condition, at pH 5.8 in an "off" condition, at pH 5.7 to 5.5 in musty condition, and at pH 5.2 and below as sour or putrid. Similar findings were reported by Hunter and Linden *(14)*, Piskur *(19)*, and Pottinger *(20, 21)*, all of whom used changes in pH and organoleptic ratings as the criteria for judging the quality of raw oysters.

Apparently, acids are formed from the breakdown of glycogen known to be distributed throughout the oysters. This breakdown is presumed to be due to bacterial action and/or glycolytic enzymes within the oyster tissue. In a basic study of glycolysis in the oyster adductor muscle, Humphry *(12, 13)* demonstrated a relatively slow production of lactic and pyruvic acids in tissue homogenates. Glycolytic activity in the oyster muscle proceeds at a much slower rate than in mammalian muscle, where all available glycogen is converted into lactic acid within a few hours under anaerobic conditions which develop within the tissues following slaughter. Apparently, no investigation has been made of glycolytic systems in other oyster tissue, although Hatanaka *(10)* found that most of the glycogen is in the soft tissues.

Investigations by the Food and Drug Administration *(8)* showed that decomposition in canned oysters is of a putrefactive type. They found no indole in the canned product prepared from raw material known to be fresh. As the amount of decomposed material present in the canned product increased, indole appeared in increasing amounts. Substantial amounts of volatile acids, including propionic, were found in sound oysters and in somewhat greater degree in decomposed oysters.

The present trend in food marketing is in the direction of more highly processed ready-to-eat products. It seemed worth while, therefore, to investigate the possibilities of prepared oyster products, especially since oysters are considered an excellent source of some nutrients and prepared products might aid in increasing their consumption. Before such products can be developed, however, the rate and type of spoilage which occurs in cooked oysters must be determined, and an effective means of preventing or retarding such spoilage must be established.

Since cooking would be expected to destroy enzymes and bacteria, one would expect the spoilage of cooked oysters to differ from that of uncooked. If cooked oysters were subsequently preserved from bacterial spoilage as by freezing or irradiation, one might expect changes in flavor and odor associated with unsaturated fat oxidation as observed in shrimp *(7)*. A progressive toughening might also be expected from protein denaturation and coagulation *(5)*, accompanied by shrinkage and water loss (syneresis). During preliminary tests it was discovered that oysters not only lose considerable weight during cooking, but that they continue to exude fluid during subsequent storage at 41° F. (5° C.). Since this continuous exudation of fluid would present a definite problem in some types of prepared oyster products, this study included an investigation of the amount of fluid exuded during cooking by different methods and during subsequent storage at two different temperatures.

EXPERIMENTAL

Raw material. All oysters used in this study were of the species *Ostrea virginica*, tonged from Cat Point Reef in the Gulf of Mexico. Some were tonged directly and others were purchased either in the shell or freshly shucked from a commercial packing house in Apalachicola, Florida.

Oysters tonged directly were packed in ice immediately and transported to the laboratory in about 3 hours. They were sometimes shucked upon arrival and sometimes kept on ice over night and shucked the following morning. They were dry shucked into their own shucking liquor and immeditely washed by suspending in tap water for approximately 30 seconds after the shucking liquor was discarded. Shell oysters obtained from the packing house had been tonged the day before being transported to the laboratory. They were not iced from the time of tonging until their arrival at the laboratory. They were immediately shucked and washed in the manner described above. After washing, the initial pH was measured and the oysters were packed in pint metal friction-top cans and stored at 41° F. (5° C.) until time of use.

Commercially shucked oysters were shucked into buckets of water at the packing house on the morning after tonging, turned out onto skimmers, sprayed with fresh water, and drained for 5 minutes before packaging in metal friction-top cans. After packaging, the oysters were packed in ice and transported to the laboratory in about 2 hours. Upon arrival, all of the oysters of each lot were mixed together in a large container and replaced in the cans so that the distribution of oysters in each can would be representative of the whole lot. The initial pH was then measured and the oysters stored at 41° F. (5° C.) until time of use.

---

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St Louis, Missouri, June 12, 1956.

[b] This paper is derived from a thesis submitted by Elizabeth Ann Gardner to the Graduate Council, Florida State University, in partial fulfillment of the requirements for the degree of Master of Science.

[c] The research reported in this paper was conducted by Florida State University under a contract with the U. S. Fish and Wildlife Service. It was financed with funds made available under provisions of Public Law 466, 83rd Congress, approved July 1, 1954, generally termed the Saltonstall-Kennedy Act. The study was made possible through the cooperation of the Oceanographic Institute, Florida State University.

Methods. All pH measurements were made with a Beckman model H2 pH meter, using the slurry of a 35-40 g. sample of oysters (3-4 oysters) which were blended in a Waring blender for about 2 minutes. Odor was rated organoleptically by one person, except on the occasion when a panel of judges was recruited to rate several products. All draining of oysters was done in a perforated aluminum frying basket and was timed at 2 minutes.

Qualitative tests for enzymes. In order that the cooked product could be duplicated and oysters compared from one experiment to another, an objective means was needed for determining the degree to which oysters had been cooked. Since it seemed that inactivation of an enzyme would be a good criterion and would require only a stimple test, preliminary qualitative tests for the enzymes catalase, peroxidase, and phenol oxidase were performed on various parts of the raw oyster in order to establish such a simple test for enzyme inactivation on heating. Neither peroxidase nor phenol oxidase were present in sufficient amounts to form the basis for such a test. However, all oyster tissues tested as well as oyster liquor gave very strong catalase tests, the addition of both 3% and 30% hydrogen peroxide resulting in a rapid and vigorous evolution of gas. Apparently, this enzyme in oysters is not inactivated by the addition of very strong hydrogen peroxide as it is in many other animal and vegetable tissues.

Heat inactivation of catalase. Preliminary tests to determine the optimum temperature and time required to inactivate the enzyme catalase were carried out on several lots of oysters. The raw oysters were drained, weighed, placed in an aluminum frying basket, and immersed in boiling distilled water. At the time of immersion, the temperature of the oysters was about 46-50° F. (8-10° C.), and this caused the temperature of the cooking water to drop considerably. When it returned to the desired temperature, it was held in a given range for various lengths of time. The oysters were then removed from the cooking water, drained, and several of the oysters chopped and tested for catalase activity with 3% hydrogen peroxide.

It was found that when a third of a pint of oysters was cooked in 1½ quarts of water, the minimum time required for complete inactivation of catalase was 1½ minutes at 194-203° F. (90-95° C.) and 3 minutes at 176-185° F. (80-85° C.). When 2 pints of oysters were cooked in 3 quarts of water, the temperature rose to 194° F. (90-95° C.) in about 2½ minutes, and ½ minute at 194-203° F. (90-95° C.) was sufficient for complete inactivation of catalase. Oysters cooked in half-pint lots in a double boiler arrangement (glass beaker immersed in boiling water), with stirring, required 3-5 minutes to reach 158° F. (70° C.) and 1 to 2 minutes at 158-176° F. (70-80° C.) for complete inactivation of catalase. As would be expected, the time required for the inactivation of the enzyme varies with the size of the oysters, the relative weight of oysters to liquid and the degree of heat applied. It is necessary to run the test with each new set of conditions.

It should be pointed out that the complete inactivation of catalase by heat does not necessarily indicate that all other enzymes have been completely inactivated at that point. In fact, the inactivation of catalase, which is used as a criterion of blanching adequacy for vegetables, has been found, in most vegetables, to occur sooner than it does with peroxidase and other oxidizing enzymes *(2, 15, 18)*. It is probable that the situation is the same in oysters.

RESULTS OF EXPERIMENTS ON COOKED OYSTERS

Effect of enzyme inactivation on spoilage pattern. Cooked oysters in which catalase had been completely inactivated were stored in glass beakers covered with aluminum foil and in metal friction-top cans at 41° F. (5° C.), and changes in odor and pH were followed. Oysters which had been cooked, but not long enough to completely inactivate the enzyme, were stored under identical conditions, as were also uncooked oysters.

Within 4 to 6 days after cooking, a "rancid fish" odor began to develop in the refrigerated oysters in which the enzyme had been completely inactivated. This odor became rapidly more pronounced during the next few days, with a slight increase in pH, followed by ultimate putrefaction. On the other hand, refrigerated oysters which had been cooked, but not long enough to completely inactivate the enzyme, developed a slightly sour odor before final putrefaction occurred. The sour odor in this case was not accompanied by a marked fall in pH as it was in the uncooked oysters. These results, presented in Table 1, indicate that the spoilage taking place in cooked oysters in which the enzyme has been completely inactivated follows a different pattern from that of raw oysters and of oysters in which the enzyme catalase has been only partially inactivated.

Addition of antioxidants to cooking water. It was assumed that the spoilage observed in the cooked oysters was probably of an oxidative type involving unsaturated fat oxidation. However, it was not possible to establish this assumption by direct analysis of the fat since the small amount of fat could not be readily extracted except by continuous extraction of the dried oysters with hot solvents. This treatment is unsuitable since it may bring about further oxidation of the fat as well as decomposition of fat peroxides *(24)*. It was necessary, therefore, to approach the problem indirectly by determining whether or not the spoilage symptoms could be inhibited by fat antioxidants.

Several primary fat antioxidants have been used with

TABLE 1

Changes in odor and pH of heated oysters stored at 5° C.

Month of year	Time held at 90-95° C. (min.)	Catalase test	pH				Days before off odor detected	Odor when spoiled
			Initial	4th day	9th day	12th day		
February	uncooked	strong	6.42	6.20	5.95	5.80	8	sour
	1	slight	6.42			6.40	6	slightly sour
	1½	neg.	6.42			6.70	4-6	rancid fish odor
	2	neg.	6.42			6.60	4-6	rancid fish odor
February	uncooked	strong	6.40	6.12	5.98	5.85	8	sour
	1	strong	6.40	6.40	6.50		6	sour
	1½	slight	6.40	6.30	6.50		6	slightly sour
	2	neg.	6.40	6.35	6.50		4-6	rancid fish odor
October	uncooked	strong	6.12	5.96	5.79	5.72	11	sour
	heating discontd. at 90° C.	slight	6.12	6.32	6.28	6.25	7	sour
	½	neg.	6.12	6.35	6.34	6.32	7	rancid fish odor
November	uncooked	strong	6.00	5.92	5.68		9	sour
	heating discontd. at 85° C.	slight	6.00	6.22	6.22		9	slightly sour
	heating discontd. at 90° C.	neg.	6.00	6.25	6.28		6	rancid fish odor

success in preventing or retarding rancidity in various fats and foods with a high fat content. Among these are butylated hydroxyanisole (BHA) and nordihydroguaiaretic acid (NDGA), phenolic compounds which have been reported as effective antioxidants for lard and other animal fats *(4, 16, 17)*. Oxidative changes in frozen shrimp have also been inhibited by BHA *(7)*. For many years natural smoke has been known to contain antioxidants which retard rancidity in fish, meats, or poultry subjected to the smoking process. Recently it has been discovered that several of the various commercial liquid smokes (prepared by collecting some of the volatile products of the thermal decomposition of wood) which are available for flavoring are also effective antioxidants in artificial aqueous lard systems, in frozen ground pork, in frozen shrimp, and in fish *(6, 7, 25)*.

Fresh oysters were cooked for 2 minutes at 194-203° F. (90-95° C.) in the manner previously described, proportions used being one pint of oysters (drained weight approximately 400 g.) to 1½ quarts of water. Final concentrations of antioxidants in the cooking water were 0.01%, 0.03%, 0.05%, and 0.10% of a commercial liquid smoke[d] and 0.05%, 0.15%, 0.25% and 0.50% of a commercial mixture[e] containing 74% propylene glycol, 20% BHA, 4% anhydrous citric acid, and 2% NDGA. As controls, some oysters were cooked in their own liquor and some in distilled water without antioxidant. Some of the oysters with and without antioxidants were packed in pint metal friction-top cans and frozen, while others were packed in glass beakers covered with aluminum foil and stored at 41° F. (5° C.). At frequent intervals refrigerated oysters were examined for changes in odor and pH. Frozen samples were examined at less frequent intervals for changes in odor only.

Results of these tests with antioxidants are presented in Table 2. When either antioxidant preparation was added to the cooking water in concentrations ranging from 0.01% to 0.50%, no "rancid fish" odor developed, and ultimate spoilage which occurred at about the end of two weeks at 41° F. (5° C.) was putrefactive. Oysters cooked with 0.05% liquid smoke or 0.25% Tennox N had developed no trace of an off odor after being in frozen storage at 5° F. (—15° C.) for as long as 8 months, while those cooked at the same time with no antioxidants and stored under identical conditions had developed a "rancid fish" odor within 4 months.

Under the conditions employed in this study, the lower concentrations of both antioxidants were just as effective in preventing the spoilage symptoms as were the higher. Whereas the BHA-NDGA mixture, which is almost odorless did not cover up the cooked oyster odor, the liquid smoke has a very strong characteristic odor of its own, and oysters cooked with smoke retained this odor until the putrid odor began to develop. The smoked oyster odor was not undesirable and there may be a market for new types of smoked oyster products.

These results indicate that spoilage occurring in completely cooked oysters is of an oxidative type with a characteristic "rancid fish" odor which can be prevented by small concentrations of primary fat antioxidants in the cooking water. When oysters are cooked with antioxidants, the spoilage which ultimately takes place is of a putrefactive nature and does not occur within 2 weeks at 41° F. (5° C.) or within at least 8 months at 5° F. (—15° C.).

The observations in Table 2 were made by the authors. To determine the acceptance of oysters frozen with and without antioxidants by a group of persons without knowledge of the treatment the different products had received, a panel of 16 persons, including the authors, was recruited to judge the odor of the cooked products. The panel was comprised of the staff members and graduate students in the Department of Food and Nutrition. Most of these persons had no specific experience with the identification or rating of the various off odors which develop in oysters, and it was therefore hoped that their judgments would be unbiased and more representative of the reaction of the general public. Those samples used were oysters which had been cooked with no antioxidant, with 0.05% liquid smoke, and with 0.25% BHA-NDGA mixture in the cooking water and frozen for 8 months, and a sample of fresh (unfrozen) oysters cooked with no antioxidant was also included. The frozen oysters had been thawed slowly in the refrigerator over night. All samples were at room temperature at the time of judging. The judges were not told what treatment the different samples had received. They were given a list of descriptive terms from which to choose one or a combination which best described the odor of each sample. If they thought that

[d] Imitation Hickory Smoke Flavour 51.675/A, Firmenich Inc., New York.

[e] Tennox N, Eastman Kodak Company, Kingsport, Tennessee.

TABLE 2

Effect of antioxidants on cooked oysters stored at 5° C.

Antioxidant used	Catalase test	Initial pH	pH after cooking	pH			Days before off odor detected	Odor when spoiled
				5th day	6th day	10th day		
None, uncooked	strong	6.35		6.00	5.95	5.85	8	sour
None, cooked in H_2O only	neg.	6.20	6.40		6.35	6.55	4-6	rancid fish odor
0.1% smoke	neg.	6.20	6.45		6.40	6.50	17	putrid
0.5% BHA-NDGA	neg.	6.30	6.50		6.40	6.55	17	putrid
None, cooked in own liquor	neg.	6.25	6.50		6.30	6.55	4-6	rancid fish odor
None, uncooked	strong	5.82		5.82	5.79	5.66	5	sour
None, cooked in H_2O only	neg.	5.82		6.10			4-6	rancid fish odor
0.03% smoke	neg.	5.82		6.19			17	putrid
0.05% smoke	neg.	5.82		6.12			17	putrid
0.10% smoke	neg.	5.82		6.19			17	putrid
0.05% BHA-NDGA	neg.	5.82		6.20			17	putrid
0.15% BHA-NDGA	neg.	5.82		6.12			17	putrid
0.50% BHA-NDGA	neg.	5.82		6.15			17	putrid

TABLE 3
Odors detected in cooked oysters by a panel of sixteen judges

Description of oysters	Number of judges ascribing each odor								
	Fresh	Stale	Musty	Sour	Fishy	Smoky	Grassy	Smoky and musty	Smoky and fishy
Cooked with 0.25% BHA-NDGA mixture and frozen for eight months	8	1			7				
Cooked with H_2O only and frozen for eight months	2	1	3	2	8				
Fresh sample cooked with H_2O only	6	2	2	2	3		1		
Cooked with 0.05% smoke and frozen for eight months				1		13		1	1

$X^2 = 39.58$. Degrees of freedom $= 24$. $P = 0.02$.

none of these terms described the odor, they were told to use a description of their own. In addition to this they were asked to rate their acceptance of the odor of each sample on a scale from 1-10, with 10 representing the most acceptable. The results are summarized in Table 3.

Rather surprisingly, more judges rated as fresh, the samples cooked with the antioxidants and frozen for 8 months than gave this rating to the freshly cooked sample from another lot of oysters. It is possible that the quality of the fresh sample was inferior to the original quality of the oysters which were frozen. The predominant off odor in the frozen oysters was fishy, and those cooked without antioxidants showed a much higher percentage of off odor ratings than those with antioxidants. All but one of the judges were able to detect the smoke odor. To determine the degree of association existing between the different odors and the treatment which the oysters had received, the Chi-square test was applied. The values obtained support the substantive hypothesis that there is a difference in odors which is associated with different treatments.

The ratings of the judges' acceptance of these odors are recorded in Table 4, and it can be seen that the individual acceptances of the odor of each sample were extremely varied. The mean of the ratings of each sample was computed, and it was found that the oysters which had been cooked with the BHA-NDGA mixture and frozen for 8 months received the highest mean rating of 6.75, with the smoke treated oysters only slightly less acceptable at a mean rating of 6.25. It was interesting that the freshly cooked oysters with no antioxidant and frozen for 8 months received the lowest mean rating of 4.69. The Chi-square test was also applied here to determine the degree of association existing between the treatment which the oysters had received and their acceptance. Because of the great spread in scores for any one sample, even the rather large differences in acceptance of the various treatments were not statistically significant.

Fluid losses during and after cooking. It was observed that oysters not only shrink and lose considerable weight during cooking, but that they continue to exude fluid during subsequent refrigerated storage. Because this would present a definite problem in some types of prepared oyster products, further study was made of the fluid losses both during and after cooking.

Two methods of cooking were employed, one a double boiler method in which fresh oysters were drained, weighed, and placed in glass beakers, ½ pint or approximately 150 g. of oysters in each of the beakers which were immersed in boiling water. When the temperature of the oysters reached 149-158° F. (65-70° C.), it was held within this range for stated times. The other method was that previously described in which the drained oysters were plunged into boiling water, the temperature of which dropped and was allowed to return to 194-203° F. (90-95° C.) within which range it was held for stated times. Proportions used were one pint of drained oysters to 1½ quarts of water.

After cooking by either of these methods, the oysters were drained and weighed to determine cooking losses, packed in glass beakers with aluminum foil covers, placed in the refrigerator at 41° F. (5° C.), and drained periodically to determine the amount of fluid which had been exuded. Some of the oysters were packed in pint metal friction-top cans and frozen at 5° F. (—15° C.) for 5 days after cooking, then removed and placed in the refrigerator to thaw for about 24 hours, after which the amount of fluid exuded was determined periodically. For comparison with the cooked oysters, drained raw oysters were stored under

TABLE 4
Acceptance of cooked oyster odors by a panel of sixteen judges rating the odors on a scale from 1 to 10, with 10 representing the most acceptable

Description of oysters	Number of judges ascribing rating											Mean rating	Standard deviation	Standard error
	0	1	2	3	4	5	6	7	8	9	10			
Cooked with 0.025 BHA-NDGA mixture and frozen for eight months		1		2	1	1		2	5	2	2	6.75	2.63	.66
Cooked with H_2O only and frozen for eight months		2	3	1	½	3	2		1	1	1	4.69	2.75	.69
Fresh samples cooked with H_2O only			3	2	3	3			2	1	2	5.25	2.74	.69
Cooked with 0.05% smoke and frozen for eight months	1	1		2	1		3	1	2	2	3	6.25	3.13	.78

$X^2 = 17.30$. Degrees of freedom $= 30$. $P = 0.97$.

identical conditions and subsequent fluid exudation determined at the same intervals.

The results of several cooking conditions on the fluid losses of oysters are summarized in Table 5. Fresh commercially shuck oysters were used in all of these experiments, and it was found that liquor comprised from 15% to 34% of the initial weight of the oysters as purchased. The percentage of weight lost during cooking, based on the drained weight of the oysters before cooking, increased as the cooking time was lengthened. At one given temperature and cooking time the loss was greater when the quantity of oysters cooked at one time was increased since a longer time was required to reach the temperature with a larger sample. No consistent difference in fluid loss during and after cooking was observed between the two methods of cooking. For the most part, regardless of the cooking method, it appears that the larger the percentage of the fluid cooked out of the oysters during the cooking period, the smaller is the total percentage of fluid which is exuded during subsequent storage at 41° F. (5° C.). Uncooked oysters also continued to exude fluid after repeated drainings, but the total loss was much less than that of cooked oysters.

Cooked oysters which were frozen for 5 days before thawing and storage in the refrigerator exuded more fluid after thawing than did the oysters which were placed in the refrigerator immediately after cooking. However, there was no way to determine whether this greater loss was due to the effect of freezing or to the fact that these samples had lost less during cooking than those samples which were not frozen.

Effect of polyphosphates on fluid losses. It is known that the coagulation of denatured protein can be retarded by various substances which will form salt bridges with exposed groups on the denatured protein molecule *(11)*. Alkaline phosphates have been recommended to prevent loss of juice and to promote tenderness during cooking of hams *(3)* and as a soaking medium prior to the cooking of shrimp *(9)*. It was thought that polyphosphates might be effective in reducing the fluid losses of oysters during and after cooking, and two such compounds were tested.

Oysters were cooked in water for 3 minutes at 194-203° F. (90-95° C.) in the manner described in the previous section on fluid losses. The cooking water contained either 0.15% sodium tripolyphosphate ($Na_5P_3O_{10}$) or 0.1% sodium "hexameta" phosphate $(NaPo_3)_x$. Some of the oysters were stored at 41° F. (5° C.) immediately after cooking, while others were frozen at 5° F. (—15° C.) and transferred to the refrigerator 5 days later. Oysters were drained and weighed periodically to determine the amount of exuded fluid.

Neither of these two polyphosphates in the concentrations used had any effect on the fluid losses either during cooking or during subsequent storage. The total fluid losses of oysters with and without polyphosphates were not significantly different. It is possible that under the conditions of this experiment, there was insufficient penetration of the phosphates to affect the proteins during the heating period.

DISCUSSION

The foregoing experiments demonstrate that the spoilage occurring in cooked oysters in which the enzyme catalase is completely inactivated is different from that observed in uncooked oysters. Furthermore, it has been shown that such spoilage in both refrigerated and frozen cooked oysters probably involves unsaturated fat oxidation since the addition of any of several known primary fat antioxidants to the cooking water retarded this spoilage. Oysters which are cooked, but not long enough to completely inactivate catalase, develop a sour odor as do uncooked oysters, but the sour odor is not accompanied by a marked fall in pH as it is in the uncooked oysters. One possible explanation of this is that the sour odor and the fall in pH which occur simultaneously in uncooked oysters may each be caused by separate and independent mechanisms rather than by the same or interdependent mechanisms.

Since the fat could not be readily extracted from the oysters in order to measure its extent of oxidation by any standard procedure, organoleptic tests were the only means of judging the quality of the cooked oysters as reflected by possible changes in the fat during preparation and storage. Organoleptic tests are subjective and their usefulness is limited by the individual's sense acuity, physiological condition, preferences, and moods, as well as by environmental and atmospheric conditions

TABLE 5

Fluid losses of oysters during and after cooking

Month	Method of cooking	Time and temperature	Qualitative catalase activity	Drained weight of oysters before cooking (gms.)	Weight lost during cooking (%)	Weight lost after 1 day at 5° C. (%)	Total days stored at 5° C.	Weight lost during total storage period (%)	Total weight lost during cooking and subsequent storage at 5° C. (%)
May	Uncooked		+	143		6.5	5	9.9	
	double boiler	1 min. at 65-70° C.	+	139	12.1	2.2	5	17.8	29.9
	double boiler	2 min. at 65-70° C.	—	148	16.2	2.8	5	21.6	37.8
	double boiler	3 min. at 65-70° C.	—	139	27.0	2.5	5	32.3	59.3
September	Uncooked		+	319		2.4	7	10.3	
	Uncooked[1]		+	331		6.4	7	12.0	
	in water	3 min. at 90-95° C.	—	663	46.2	0.9	7	3.0	49.2
	in water[1]	3 min. at 90-95° C.	—	653	44.4	2.8	7	7.2	51.6
	double boiler	3 min. at 65-70° C.	—	784	48.6	1.0	7	4.3	52.9
	double boiler[1]	3 min. at 65-70° C.	—	712	35.4	5.7	7	11.2	46.6
October	in water	to 90° C.	+	683	20.0	8.2	3	14.1	34.1
	in water	½ min. at 90-95° C.	+	630	37.2	6.3	3	10.4	47.6
	double boiler	to 70° C.	+	305	14.0	2.0	3	3.0	17.0
	double boiler	2 min. at 70-80° C.	—	337	46.1	2.2	3	3.4	49.5

[1] Frozen for five days at —15° C., then transferred to the refrigerator (5° C.).

at the time of sampling. Many attempts have been made to use chemical and other objective tests to measure the changes associated with spoilage and the development of odoriferous products, thus eliminating the inherent limitations of organoleptic procedures. Among such methods is that which has been used by Turner and associates *(23)* to measure rancidity in frozen pork. The principle of the test is the reacting of the products of fat oxidation with thiobarbituric acid (TBA) to produce a red colored compound which may then be estimated spectrophotometrically. The advantage of this test is that it can be run directly on tissue, and the fat does not have to be extracted. Work is now in progress in this laboratory in an attempt to adapt this method to the measurement of fat oxidation in cooked oysters.

It is interesting that weight loss of oysters during cooking ranged from 17% to 59%, including values obtained for all cooking times and methods. When the heat treatment was sufficient to destroy the enzyme catalase, losses ranged from 38% to 59%. These values are much higher than that of 10% cook drip reported by Sumerwell *(22)* for fresh Pacific oysters. This may be due to difference in moisture content between Pacific and Southern oysters and also to the different method used by Sumerwell. His samples were placed on mesh racks in flat half-pound tins which were covered and immersed in boiling water until the internal temperature of the samples reached 150° F. (66° C.). The cans were then cooled in cold water and opened, the cook drip in the bottom of the can drained off, and the percent loss in weight calculated.

It would be interesting to follow the seasonal variation in moisture content of Southern oysters and to determine the degree of correlation of this with fluid losses during cooking and subsequent storage. Further investigation of fluid losses during and after cooking and of possible means of preventing or minimizing such losses is necessary before any recommendations can be made. Not only flavor, but probably some of the nutritive value of the oysters is lost in the cooking liquid. The composition of this cooking liquid and possible methods of utilizing it in prepared oyster dishes such as stews should also be investigated in future work.

SUMMARY

Raw Southern oysters were found to give an exceptionally strong qualitative test for the enzyme catalase with 3% hydrogen peroxide. This test was used to indicate inactivation of this enzyme by heat treatment.

Spoilage which took place in oysters cooked enough to inactivate catalase and subsequently frozen or refrigerated appeared to be of an oxidative type, characterized by a "rancid fish" odor. By adding various antioxidants to the cooking water, this type of spoilage was retarded.

Weight losses during cooking were influenced more by length of cooking time than by type of cooking method. Further losses of liquid took place upon refrigerated storage of the cooked oysters. Total weight losses ranged from 17% to 59% in oysters which were cooked and subsequently stored at 41° F. (5° C.), whereas losses in uncooked oysters held under the same conditions of storage were from 10% to 12%.

The addition of a polyphosphate at 0.1% and 0.5% levels in the cooking water had no effect on fluid losses during cooking or subsequent storage.

LITERATURE CITED

1. Baldwin, W. H., Puncochar, J. F., and Pottinger, S. R. Some preliminary studies on the relative value of methods for indicating quality of shucked oysters. U. S. Fish and Wildlife Service *Bull, F. I. 2468-K* (1941).
2. Bedford, C. L., and Joslyn, M. A. Enzyme activity in frozen vegetables. Stringbeans. *Ind. Eng. Chem.*, **31**, 731 (1939).
3. Brissey, G. E. Preparing Cooked Cured Meats, U. S. Patent 2,596,067 (1952).
4. Dugan, L. R., Kraybill, H. R., Ireland, L., and Vibrans, F. C. Butylated hydroxanisole as an antioxidant for fats and foods made with fat. *Food Technol.*, **4**, 457 (1950).
5. Dyer, W. J. Protein denaturation in frozen and stored fish. *Food Research*, **16**, 522 (1951).
6. Erdman, A. M., Watts, B. M., and Ellias, L. C. Smoke flavor and ascorbic acid as preservatives for fatty fish. *Food Technol.*, **8**, 320 (1954).
7. Faulkner, M. B., and Watts, B. M. Deteriorative changes in frozen shrimp and their inhibition. *Food Technol.*, **9**, 632 (1955).
8. Food and Drug Administration. Decomposition in canned oysters and clams. *J. Assoc. Offic. Agr. Chem.*, **29**, 89 (1946).
9. Garnatz, G., Volle, N. H., and Deatherage, F. E. Processing of Shrimp. U. S. Patent 2,488,184 (1949).
10. Hatanaka, M. Chemical composition of the oyster, *Ostrea Gigas* Thunberg. *Z. Untersuch. Lebensm.*, **81**, 72 (1941).
11. Haurowitz, F. *Chemistry and Biology of Proteins.* 1950. Academic Press, Inc., New York.
12. Humphry, G. F. Glycolysis in extracts of oyster muscle. *Austr. J. Exptl. Biol. Med. Sci.*, **22**, 135 (1943).
13. Humphry, G. F. Glycolysis in oyster muscle. *Austr. J. Exptl. Biol. Med. Sci.*, **28**, 151 (1950).
14. Hunter, A. C., and Linden, B. A. An investigation of oyster spoilage. *Am. Food J.*, **18**, 358 (1923).
15. Joslyn, M. A., and Bedford, C. L. Enzyme activity in frozen vegetables. Asparagus. *Ind. Eng. Chem.*, **32**, 702 (1940).
16. Kraybill, H. R., Dugan, L. R., Beadle, B. W., Vibrans, F. C., Swartz, VeN., and Rezabek, H. Butylated hydroxyanisole as an antioxidant for animal fats. *J. Am. Oil Chemists' Soc.*, **26**, 449 (1949).
17. Lehman, B. T., and Watts, B. M. Antioxidants in aqueous fat systems. *J. Am. Oil Chemists' Soc.*, **28**, 475 (1951).
18. Moyer, J. C., and Stotz, E. The blanching of vegetables by electronics. *Food Technol.*, **1**, 252 (1947).
19. Piskur, F. T. Preliminary study of correlation of pH and quality of shucked Pacific oysters. *Comm. Fish. Rev.*, **9** (6), 22 (1947).
20. Pottinger, S. R. A study of strictly fresh commercially shucked eastern oysters. *Comm. Fish Rev.*, **13** (11a), 8 (1951).
21. Pottinger, S. R. Frozen Atlantic oyster investigations. *Food Technol.*, **6**, 28 (1952).
22. Sumerwell, W. N. Determination of cook drip in Pacific ocean perch *(Sebastodes alutus)* and Pacific oysters *(Ostrea gigas)* by use of a new method. Final phase report—Chemical and physical properties of fish and shellfish proteins. Fishery Technological Laboratory, Seattle, Washington, Project 301-S.
23. Turner, E. W., Paynter, W. D., Montie, E. J., Bessert, M. W., Struck, G. M., and Olson, F. C. Use of the 2-thiobarbituric acid reagent to measure rancidity in frozen pork. *Food Technol.*, **8**, 326 (1954).
24. Watt, D. B., Hall, J. L., Mackintosh, D. L., and Vail, G. E. Heat stability of fat peroxides. *Food Technol.*, **3**, 206 (1949).
25. Watts, B. M., and Faulkner, M. Antioxidant effect of liquid smokes. *Food Technol.*, **8**, 158 (1954).

The Effect of Copper Contamination upon The Development of Color in the Processing and Storage of Honey[a]

E. Einset [b] and Walter L. Clark [c]
School of Nutrition, Cornell University, Ithaca, New York

(Manuscript received June 21, 1956)

COPPER HAS BEEN FOUND to be objectionable in many foods because of its well-known deleterious effects upon ascorbic acid and fats *(4)*. This has not been the problem in honey since it contains little lipid material with the exception of beeswax, and only minute traces of ascorbic acid. A question raised by honey processors, however, was whether copper equipment was detrimental to the quality of honey, especially with respect to its color. It was believed that, if any effect of copper on honey color could be demonstrated, it would involve an increased rate and/or degree of darkening of the product in processing and/or storage.

Review of the literature. One of the few reports in the literature concerning copper concentration in honey indicates that a broad range may be expected *(1)*. This has been found to be true for both dark and light floral honeys. On making analyses of the ash of twenty-two honeys selected at random from widely separated localities, Schuette and Remy *(8)* found copper to be one of the three predominating minerals in their samples. Table 1 shows the quantities found, and also seems to indicate a direct relationship between mineral content and degree of darkness in color.

TABLE 1

Variation in ash, silica, iron, copper and manganese content of light and dark floral honeys (8)

Component	Light			Dark		
	mg./kg.			mg./kg.		
	min.	max.	av.	min.	max.	av.
Ash[1]	0.04	0.16	0.06	0.07	0.52	0.17
Si	7.20	11.70	8.90	5.40	28.30	14.00
Fe	1.20	4.80	2.40	0.70	33.50	9.40[2]
Cu	0.14	0.70	0.29	0.35	1.04	0.56[2]
Mn	0.17	0.44	0.30	0.52	9.53	4.09

[1] Ash reported in percent.
[2] Averages based on six samples. All other averages based on ten samples.

Data of Browne *(1)*, Elser *(3)*, and Sundberg *(9)* also support this conclusion of a higher percentage of ash being associated with a darker honey. This does not necessarily mean, however, that the color is the direct consequence of a higher mineral content.

Since the color of honey is of primary importance from a quality standpoint, a determination of the extent to which metallic copper would go into solution in honey during processing was desirable, along with a study of its effect upon color in storage. As Table 1 bears out, dark honeys on the average contain more copper than light honeys. In order to ascertain whether or not the two honeys would respond differently to processing and storage conditions, experiments were carried out which included both the light and dark types of honey.

EXPERIMENTAL PROCEDURES

Samples. Dark buckwheat honey and light clover honeys were obtained from new combs gathered in New York State.

Processing. The comb honeys were extracted by filtering through several layers of copper-free cheesecloth. Suitable aliquots of the honeys were then transferred to a series of large test tubes, 25 x 200 mm., in which the different treatments with respect to copper, temperature and time were carried out. The processing consisted of immersing a motor-driven copper blade (3 x 18 x 130 mm.) into the honey and allowing it to revolve for a specified length of time. The temperature was held constant using a water bath. For each copper-treated sample, a corresponding blank sample was obtained using a glass propeller. In this manner, appropriate comparisons of treated and non-treated honeys with respect to color intensity and copper content could be made.

Color measurement. Immediately after this initial treatment, intended to simulate a broad range of processing conditions, duplicate samples from each batch were transferred to 18 x 150 mm. pre-selected test tubes, and their percent transmission of light measured in a Coleman Universal Spectrophotometer, Model 14, using filter PC-4 at 640 mμ, a convenient reference point for comparing relative color changes in honey.

After taking the initial readings, the tubes of honey were placed in an incubator at 122° F. (50° C.) including the unheated control samples. Thereafter, measurements were made at appropriate intervals.

The reference standards were untreated samples of light and dark honeys, having been stored at room temperature. Changes in the reference standards were followed by checking their percent transmission against distilled water.

Ashing. Each sample of honey which was processed with copper was analyzed for that metal. A number of analyses were also made on uncontaminated samples, both heat-processed and untreated. A wet-ash was employed, utilizing nitric acid, sulfuric acid, and perchloric acid.[4]

[a] Presented at the Fifteenth Annual Meeting of the Institute of Food Technologists, Columbus, Ohio, June 13, 1955.

[b] Present address: Department of Food Technology, University of California, Berkeley, California.

[c] Present address: Department of Food Research, Research Division, American Cyanamid Company, Pearl River, New York.

[4] The exact ashing treatment varied somewhat from one group of samples to another. In general the procedure was as follows: 20 grams of honey are weighed into a 150 ml. beaker. Twenty ml. of glass-distilled water are added, and the mixture swirled to obtain a uniform solution. Next, 5 to 10 ml. of glass-distilled, concentrated HNO_3-water mixture (1:1) are added followed by one ml. concentrated H_2SO_4. After mixing, heat is applied *with care*. Swirling occasionally is desirable in order to avoid the formation of a foam layer. Foaming can not be completely avoided, but when it has subsided somewhat, additional quantities of the HNO_3-water mixture are added, care being taken not to let the solution become too viscous. In the same way, the heating rate is increased as the foaming danger subsides. During the operation, the beakers are kept covered with watch glasses. Toward the end of the ashing, e.g. when the samples are water-clear and reduced in volume to 1-2 ml., a few drops of 60% perchloric acid are added and the samples taken to dryness. Then the ash is taken into solution and made to 25 ml. with 2 N glass-distilled HCl. An ashing blank is included with each batch of samples.

About one-half of the samples were ashed using Dow Corning Antifoam A, a silicone defoamer. One drop of this material was added to the sample prior to the addition of acid. The danger of uncontrollable foaming was virtually eliminated, and less acid was required. At the temperature used, however, the total ashing time was not appreciably shortened.

After ashing, analyses for copper were made by the procedure outlined below.

Copper analysis. A modification of the procedure reported by Parks and co-workers *(6)* for the quantitative determination of copper was adopted *(7)*. Readings were taken on a photoelectric colorimeter as described by Ellis and Brandt *(2)*.

RESULTS AND DISCUSSION

Copper anaylsis. A summary of the data obtained from the analyses for copper in the honey samples is presented in Table 2. These results are based on single determinations for each honey sample. For determining the amount of copper picked up by the samples through copper treatment, an average base value for the controls and the honey samples without the presence of copper at 30 min./100° F. (37.8° C.) and 300 min./140° F. (60° C.) was calculated. The net pickup was obtained by difference.

TABLE 2

Concentration of copper in samples of treated and untreated honey

Treatment		Dark honey meg. cu/gm.		Light honey meg. cu/gm.	
Time (min.)	Temperature (° F.)	As found	Picked up	As found	Picked up
5	100 Cu[1]	1.80	0.43	0.47	0.28
30	100 Cu	2.10	0.73	0.47	0.28
30	100	1.40	.....	0.17	.....
300	100 Cu	2.00	0.63	0.53	0.34
5	140 Cu	1.70	0.33	1.10	0.91
30	140 Cu	1.70	0.33	1.10	0.91
60	140 Cu	1.80	0.43	0.62	0.43
300	140 Cu	1.80	0.43	1.10	0.91
300	140	1.40	.....	0.22	.....
0.5	180 Cu	1.40	0.03	0.31	0.12
5	180 Cu	1.70	0.33	1.20	1.01
Untreated control		1.30	.....	0.18	.....

[1] Cu = Samples treated with metallic copper.

Color measurement. Regarding variances in honey with respect to the absence or presence of copper, the colorimeter data from the accelerated storage test indicate that under the conditions studied, contamination with additional amounts of metallic copper has no observable effect upon color development in honey as portrayed in Figure 1.

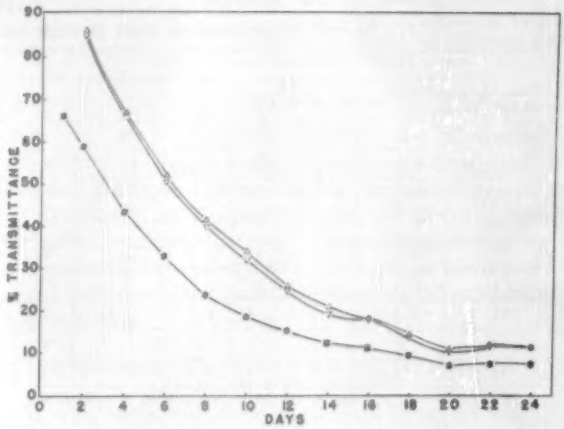


Figure 1. Effect of storage at 122° F. (50° C.) on the color of dark buckwheat honey after processing for 30 minutes in the presence and absence of copper at various temperatures.

Key	
Symbol	Treatment
▲——▲	100° F. (37.8° C.) for 30 minutes in the presence of copper.
▼——▼	100° F. (37.8° C.) for 30 minutes in the absence of copper.
△——△	140° F. (60° C.) for 30 minutes in the presence of copper.
▽——▽	140° F. (60° C.) for 30 minutes in the absence of copper.

Figure 1 is a typical graph of the effect of storage at 122° F. (50° C.) on the color of dark buckwheat honey after processing, in this case for 30 minutes, in the presence and absence of copper at two temperatures. It may readily be seen in Tables 3 and 4 that blanks and copper treated samples are essentially indistinguishable colorimetrically.

Concerning variances in honey with respect to times and temperatures in processing, it is apparent (see Table 3) that light clover honey shows no differences over the range of conditions studied with one exception. Slightly lower percent transmission values were obtained with the sample and blank processed at 140° F. (60° C.) for 5 hours. The percent transmission of the light honey decreased very gradually over the period of 24 days.

For the dark buckwheat honey the initial effects of varying time and temperature in processing (see Table 4) are somewhat more variable, although a 24 day incubation period seems to nullify these differences. The indication is that both time and temperature of processing influence initial color development. Irrespective of the time element in processing, the honey treated

TABLE 3

The percent transmission of light through clover honey as influenced by processing and storage

Storage at 122° F. (50° C.) (Days)	Treatment																		Unheated control	Reference standard
	100° F. (37.8° C.)						140° F. (60° C.)								180° F. (82° C.)					
	5 min.		30 min.		300 min.		5 min.		30 min.		60 min.		300 min.		0.5 min.		5 min.			
	Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu			
0	98	100	100	100	98	96	100+	100+	100+	100+	100+	100+	100	99	100+	100+	100+	100+	98	65
5	94	96	96	95	95	94													96	65
6							97	96	93	93	93	93	89	89	94	95	93	96		66
16	88	89	89	88	87	87	90	90	89	90	88	89	86	84	90	90	89	90	89	66
24	87	87	88	87	85	86	89	87	86	86	86	85	81	82	87	87	86	87	89	67

TABLE 4

The percent transmission of light through buckwheat honey as influenced by processing and storage

Storage at 122° F. (50° C.) (Days)	Treatment																			
	100° F. (37.8° C.)						140° F. (60° C.)								180° F. (82° C.)				Unheated control	Reference standard
	5 min.		30 min.		300 min.		5 min.		30 min.		60 min.		300 min.		0.5 min.		5 min.			
	Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu		Cu			
0	66	56[1]	66	65	10[1]	69	100+	100+	100+	100+	100+	99	82	78	88	79	43	32	99	30
2	48	44	46	46	17[1]	48	76	78	75	74	75	74	59	59	59	54	29	22	74	28
4	36	32	33	33	13[1]	33	57	57	56	54	54	53	42	41	45	39	22	16	56	26
6	25	23	23	23	10[1]	24	44	44	42	41	40	39	30	30	34	29	17	12	40	26
12	9	9	8	8	4[1]	8	21	20	18	17	16	16	12	12	16	13	8	6	14	25
18							10	9	8	7	7	6	5	5	7	5	3	2		
24	2	2	1	1	5[1]	2	5	5	4	4	4	3	3	3	4	3	2	2	3	24

[1] Unreliable readings due to air bubbles introduced in processing.

at 140° F. (60° C.) is least affected colorimetrically by temperature.

In order to explain the color development in honey during processing, the excellent browning review of Hodge *(5)* can be cited. He places great significance and emphasis on the occurrence of the Amadori rearrangement in the Maillard reaction and outlines a general mechanism for browning in carbonyl amine systems based upon this rearrangement. Briefly, in the initial stage, a sugar-amine condensation occurs forming an N-substituted glycosylamine which rearranges to 1-amino-1-deoxy-2-ketose, the Amadori rearrangement product. Three reactions can take place at the intermediate stage, sugar dehydration, sugar fragmentation, and amino acid degradation. Highly colored compounds are formed in the final stage through aldol condensation and aldehyde-amine polymerization. These reactions are known to occur in model browning systems, but the extent to which each represents color formation in honey is unknown. It should be noted that both acid conditions and the presence of amino acids accelerate various steps of the above mentioned reactions. Hence color development in honey could very readily arise due to its very own nature and composition, especially when heated.

To return to the question as to whether the mere use of copper in processing equipment is to be avoided, it appears that such a recommendation is unfounded. This statement is made with the assumption that the metal is not allowed prolonged contact with honey such as might occur in a storage container or under unsanitary processing conditions.

It should be realized that floral honeys as they occur in nature contain catalytic amounts of copper and other metals. This situation, of course, may mask a detectable effect of copper in honey color development.

SUMMARY

Samples of dark and light floral honeys have been treated in the presence and in the absence of copper metal, at different temperatures and for varying lengths of time. Samples exposed to copper contamination contained a higher level of copper than their respective controls without copper treatment. This difference was not reflected in percent transmission for color development during storage at 122° F. (50° C.).

Initial differences in percent transmission could be markedly influenced by times and temperatures of processing only in the case of dark buckwheat honey. These differences decreased rapidly during storage, however. It is of interest to note that samples of both dark and light honeys which received no treatment of any kind and ranked with the lowest in copper content, showed percent transmission values after about three weeks incubation at 122° F. (50° C.) along the same order as those samples most heavily contaminated with copper.

Acknowledgments

The authors are grateful to Professors E. J. Dyce and R. A. Morse of the Department of Entomology at Cornell University for supplying experimental material and helpful information.

Appreciation is expressed to V. Lazar, Soil Scientist, U. S. Nutrition Laboratory, Ithaca, N. Y., for assistance in the copper analyses.

LITERATURE CITED

1. Browne, C. A. Chemical analysis and composition of American honeys. U. S. Dept. Agr., *Bull. 110*, 22 (1908).
2. Ellis, G. H., and Brandt, C. S. Photoelectric colorimeter for use in microanalysis. *Anal. Chem.*, **21**, 1546 (1949).
3. Elser, E. Vergleichende Untersuchung der Aschenbestandteile bei verschiedenen Honigtypen. *Archiv. Bienenkunde*, **7**, 276 (1926).
4. Gortner, R. A. *Outlines of Biochemistry*, 3rd ed., 1949, pp. 780 and 912. John Wiley & Sons, Inc., New York, N. Y.
5. Hodge, J. E. Chemistry of browning reactions in model systems. *J. Agr. Food Chem.*, **1**, 928 (1953).
6. Parks, R. Q., Hood, S. L., Hurwitz, C., and Ellis, G. H. Quantitative chemical microdetermination of twelve elements in plant tissue. A systematic procedure. *Ind. Eng. Chem., Anal. Ed.*, **15**, 527 (1943).
7. Lazar, V. (Personal communications, 1954).
8. Schuette, H. A., and Remy, K. Degree of pigmentation and its probable relationship to the mineral constituents of honey. *J. Am. Chem. Soc.*, **54**, 2909 (1932).
9. Sundberg, T., and Lundgren, A. Untersuchung uber die Aschenbestandteile in schwedischem Honig. *Archiv. Bienenkunde*, **11**, 324 (1930).

Automatic Pilot Plant Control in the Development of Microorganisms[a, b]

George J. Fuld and Cecil G. Dunn
Department of Food Technology, Massachusetts Institute of Technology, Cambridge 39, Mass.

(Manuscript received June 13, 1956)

LARGE-SCALE DEVELOPMENT of submerged fermentations and the many advances in the field of instrumentation within the last ten years have opened vast new fields for the application of automatic control to the fermentation industries. Increasing use of continuous processes has made the adaptation of integrated control to fermentation processes highly desirable and possibly even mandatory.

Since the publication of Hayduck's patents *(7)*, various attempts have been made to keep the sugar concentration at a low level in a yeast propagation medium by the continuous, or concomitant addition of sugar. The types of feed systems used include a punched steel ribbon which operates a mercury tumbler that opens a a valve *(1, 14)*, a variable orifice centrifugal pump *(4)*, weir type calibrated valves *(15)*, peristaltic pumps controlled by a "percent-input" timer *(12)*, and various types of positive displacement pumps *(16)*. These systems all add sugar at a predetermined rate. No reports have been found in the literature describing a feedback control device that automatically supplies the sugar required by actively growing yeast. The possible utilization of such a device has been investigated extensively by the authors. The first problem was that of the development of a control device by means of which the sugar concentration, or some function thereof, could be measured continuously at the levels most likely to be encountered in fermentations.

Three possible means of measuring sugar concentration have been considered; these are namely, the measurement of: specific gravity, optical rotation, and refractive index. Although several devices for the determination of specific gravity or density are available at the present time *(8)*, it was considered that with the sensitivity required, concurrent variables would have too large an effect on the actual readings obtained. Density values are highly sensitive to changes in temperature, dissolved gases and compounds of low molecular weight which would cause the readings of sugar concentration to be erroneous.

Optical rotation measurement would be a highly sensitive measuring device and, since only optically active compounds would be measured, it would be less subject to interference from compounds other than those that it is desired to control. However, yeast cells contain large amounts of the enzyme invertase which causes the ratio of sucrose to glucose to change continuously throughout a fermentation process. This is of considerable importance when sucrose-containing material is used as a sugar source. Since the optical rotation of glucose is drastically different from that of sucrose, continuous correction for this variation would be necessary. At the present time, no device is commercially available that will measure optical rotation continuously, but undoubtedly one could be constructed along the lines of the various continuous refractometers now available.

INVESTIGATION OF THE REFRACTIVE INDEX AS A CONTROL DEVICE

It was, therefore, decided to investigate the use of refractive index as a means of measuring and correlating sugar concentration. Although refractive index measurement is a widely used method for measuring sugar concentrations *(2)*, there are problems associated with its use in the fermentation field. The mash, for example, contains microorganisms and the products of fermentation in addition to the sugar which may be present only in relatively low concentrations.

Laboratory experiments were performed, using shake-flask cultures, to determine the variation of the refractive index of the medium with time. Analyses were made periodically on a cell-free sample for gross refractive index, pH, sugar concentration, employing Sullivan's micromethod *(13)*, which utilizes cereous sulfate, alcohol concentration, involving the oxidation of volatiles by chromate ion as described by Neish *(10)*, and the total nitrogen as ammonia, utilizing an electrometric formol titration developed by Fuld *(5)*. If the increments of refractive index due to the particular concentration of the compounds, such as nitrogen, alcohol or sugar, are summated and then subtracted from the gross refractive index of the medium, a value which may be designated as the "net refractive index" is obtained. Results of a typical experiment in which a strain of *Saccharomyces cerevisiae* was grown on a synthetic medium *(11)* are shown in Figure 1. All the sugar, as glucose, was added initially. The curve for net refractive index is very nearly a straight line, indicating that the refractive index measurement can reasonably be used as a measurement of sugar concentration in the fermentation. However, great variations in the concentration of alcohol, nitrogen and phosphorus would affect the net refractive index of the medium.

It was determined that when incremental sugar addition was attempted with the shake-flask cultures, the net refractive index deviated from a constant value towards the end of the fermentation especially when molasses was used as a sugar source. Typical curves for net refractive index derived from duplicate runs, using molasses as a sugar source, are shown in Figure 2. Molasses apparently contains some non-metabolizable fractions that affect the refractive index. An empirical relation, referred to a basis of increments of refractive index due to the non-metabolizable fraction on the basis of color intensity can then be used to correct

[a] Presented before the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 12, 1956.

[b] The results presented herewith form a part of the Sc.D. thesis presented in the Department of Food Technology, Massachusetts Institute of Technology, by G. J. Fuld, in 1956. Contribution No. 297 from the Department of Food Technology.

the net-refractive index. The results corrected on this basis are shown in Figure 2. Results of laboratory experiments were reasonably promising, and an attempt to control the sugar on a truly continuous basis, with the utilization of refractive index as the control device, was made.

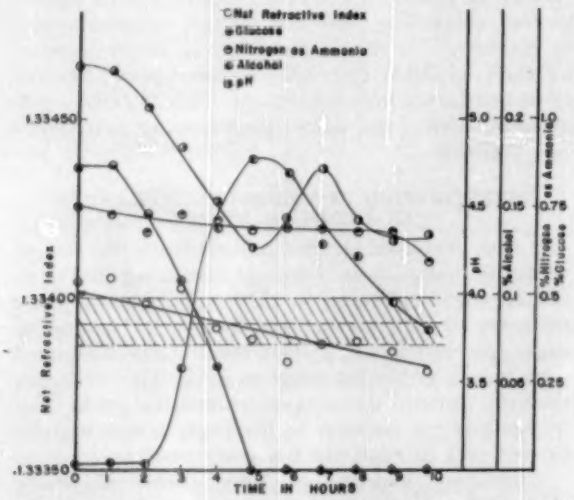


Figure 1. Run C. Yeast SBI-1, in synthetic medium of Olsen and Johnson, grown on shake flask propagator at 30° C.

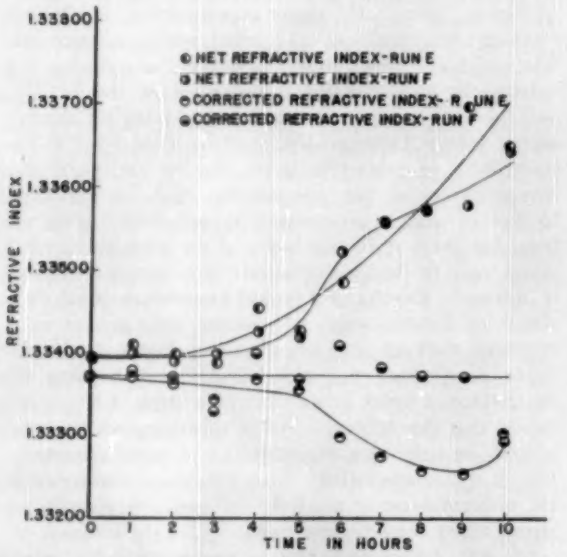


Figure 2. Net refractive indices for runs E and F before and after correction by empirical color intensity.

DESCRIPTION OF APPARATUS USED

The apparatus used for the large-scale studies consists of a stainless steel, jacketed, reactor of 55-gallons capacity and the necessary accessory equipment. The general appearance of the pilot plant is shown in Figure 3. Detailed schematics of the equipment are presented elsewhere *(5)*.

Accessory equipment includes a number of essential facilities. A temperature recorder-controller operates a dual control type valve system, which feeds either steam or cold water to the jacket of the reactor. An overhead variable-speed agitator, equipped with a turbine impellor blade and 4 laterally mounted baffles in the tank provide adequate agitation. A sterile, preheated, humidified air supply is obtained by passing the air through a carbon-packed filter, that is equipped with a steam jacket and then through a humidifier. A rotameter and needle valve, mounted on the central panel control the air flow. Air enters the reactor and impinges onto the impellor blade, thus being dispersed throughout the liquid. Means for steam sterilization of the entire apparatus, including all lines, reservoirs and the air filter is provided on the central panel. Steam seals are present on the sample line, the product line and the removable hand-hole.

An automatic antifoam system is provided by a high-level probe and a low impedance relay. The signal is transmitted through a time-delay device (consisting of a synchronous motor, a cam, and a micro-switch) to a solenoid valve.

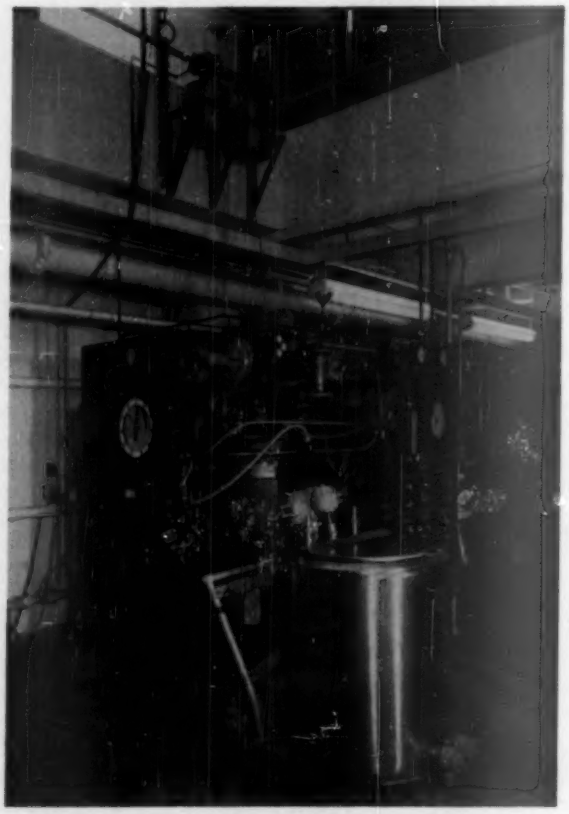


Figure 3. A view of the 50-gallon pilot plant fermentor.

The pH control system is shown schematically in Figure 4. It consists of a small centrifugal pump which continuously circulates the medium past the pH electrodes. The recorder-controller operates a diaphragm valve which meters in a supply of base as it is required from a 5-gallon pressure reservoir. A pressure balance line maintains reactor pressure in the vessel so that the flow is by gravity. Samples are taken from this circulation system. Thus, fresh samples may always be obtained aseptically. There is a steam seal at this outlet to help to maintain sterility.

Since the presence of suspended yeast cells causes the light to be diffused sufficiently to prevent the formation of a definite image in the field, a clarification step is mandatory. Hence, the sugar control system contains a branch line from the circulating system that discharges a stream of medium through a Westphalia LWA 205 centrifuge. The clarified liquor then passes through a Bausch and Lomb control refractometer *(3)* and is then returned to the fermentor.

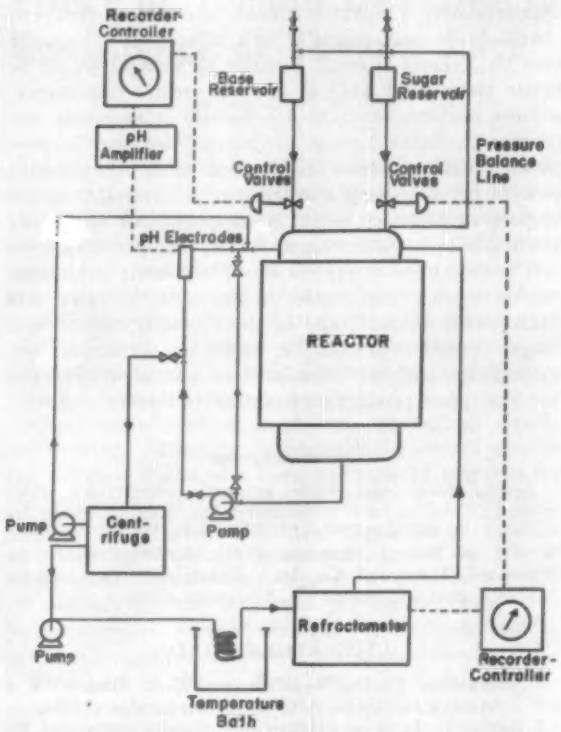


Figure 4. Schematic diagram of pH control and sugar control on the 50-gallon fermentor.

RESULTS AND DISCUSSION

Several experiments have been performed that utilize the automatic control system with the pilot plant fermentor. The results of one run are shown in Figure 5. Curves are shown for the yeast production, total molasses addition, nitrogen present in the medium, alcohol production and the actual sugar concentration present. The first control point was at 0.70% and thereafter the value slowly decreased with time.

A chart showing the variation of sugar concentration with time is shown as Table 1. The average sugar concentration during control was 0.58 ± 0.16%. However, since the alcohol production was excessive, probably due to insufficient aeration, the alcohol affected the controlled refractive index appreciably. If the effect of the alcohol is taken into account and the correction taken as sugar, the hypothetical sugar concentration that would have been present in the absence of appreciable alcohol, is shown in the fourth column. The average concentration would have been 0.63 ± 0.13%.

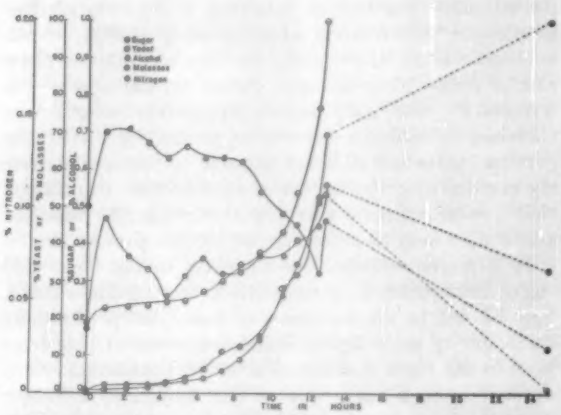


Figure 5. Bakers' yeast propagation (run No. 66) with automatic sugar and pH control.

Experiments are planned so that the alcohol production will be held to a minimum. Analyses for phosphorus concentration during the fermentation were made *(9)* and it was found that an excess was present. The concentrations are shown in column 5 of Table 1. When corrections were made for both the phosphorus and the alcohol, a different, hypothetical sugar concentration was found; this is shown in the last column. In this case the average, hypothetical sugar concentration would have been 0.64 ± 0.10%. Adjustment for the alcohol production and the phosphorus variation apparently accounts for most of the errors in the controlled system. However, there appears to be a non-negligible decrease in the sugar concentration with time, which in this case amounts to 0.16% sugar. Subsequent runs using both molasses media and synthetic media with either hydrolyzed corn sugar ('Cerelose')

TABLE 1

Bakers' Yeast Propagation
150 litres in molasses medium—Run No. 66

(Time (hours)	Actual sugar (percent)	Alcohol (percent)	Hypothetical sugar (corrected for alcohol)	Phosphorus (percent)	Hypothetical sugar (corrected for alcohol and phosphorus)	Remarks
0	0.50	0.003	.....	0.0112	.....	(not controlled)
1.00	0.70	0.004	0.70	0.0188	0.70	
2.23	0.71	0.011	0.71	0.0191	0.71	
3.23	0.67	0.016	0.67	0.0178	0.67	
4.31	0.63	0.022	0.64	0.0188	0.64	
5.31	0.66	0.024	0.67	0.0193	0.67	
6.31	0.63	0.036	0.64	0.0188	0.64	
7.31	0.63	0.056	0.65	0.0223	0.66	
8.31	0.62	0.088	0.65	0.0252	0.66	
9.35	0.54	0.142	0.59	0.0300	0.61	
10.55	0.48	0.281	0.58	0.0425	0.61	
11.31	0.45	0.317	0.56	0.0475	0.60	
12.52	0.32	0.513	0.50	0.0470	0.54	(All molasses
12.87	0.51	0.532	0.70	0.0795	1.77	utilized—not
24.48	0.12	0.008	.....	0.0595	.....	controlled)
Average of controlled sugar conc.	0.58 ± 0.16		0.63 ± 0.13		0.64 ± 0.10	

or sucrose as a carbon source have shown a decrease in the corrected sugar concentration, which varies from 0.10% to 0.30%. It has been possible to maintain the phosphorus concentration constant to within 0.01% so that its variation should have a negligible effect on the controlled sugar value. However, even when the controlled sugar was held to less than 0.25%, the alcohol production still reached approximately 0.30%, which is considered to be too high. In these cases an aeration rate of about 10 ft. per sec. (based on the area of the fermentor) was used—which apparently is still not sufficient to minimize the alcohol production. With the present equipment it is not possible to further increase the aeration rate without major modification. It is hoped that a more efficient sparging system can be installed which may help to minimize the alcohol production.

It is considered that the decrease in the controlled sugar concentration, even when corrected for alcohol, may be due to the excretion of metabolic products by the respiring yeast and to some non-metabolizable fractions in the sugar sources. The latter consideration was verified when a sugar source that contained a known amount of non-metabolizable fractions was used. Further details of this work will be reported in a subsequent paper *(6)*.

This slight decrease in sugar concentration with time has the disadvantage that it sets a minimum value below which it is not possible to achieve adequate control. Thus, if the alcohol yield maximum is 0.60% and the decrease in control due to non-metabolizable fractions is 0.16%, the minimum possible sugar control is 0.40%. If it is attempted to control below this value, it is possible that the sugar will eventually approach zero concentration which will suspend the active growth of the yeast. However, a slightly decreased sugar concentration may be advantageous in that it may, especially at the peak of growth, cause a lower alcohol production.

The refractive index controller was capable of control to a value equivalent to $\pm 0.06\%$ sugar. In the later part of this particular run the sensitivity of the controller was doubled, but the magnitude of the deviations remained approximately the same.

During control, the pH was held constant at 5.05 ± 0.05 units. At the end of the active growth period, the yeast cells autolyzed and the pH rose slowly to about 7.0.

The temperature throughout the fermentation was held at $30.0 \pm 0.3°$ C. by the automatic temperature control system.

The results presented thus far are only preliminary. A system, such as the one described herein, for pilot plant studies may be used on a large-scale unit, the only change necessary being an adjustment in the size of the control values. Such a control device might cost approximately $15,000 to install in a plant. It would obviously be only practical if it offered an advantage over the present system. Possible advantages would be better yields, and what is of even greater importance, a more uniform product. Uniformity is especially important in bakers' yeast propagated for use in continuous baking where exact predictable fermentative powers per unit weight are needed. Naturally, such a sugar control device would be invaluable for laboratory studies since optimum sugar levels, that are very difficult to determine at present could be found. Additional studies to determine better media, aeration rates, and yeast strain studies could be more readily carried out. Sugar control might also be useful for continuous fermentations, such as those used in several installations for food yeast production from sulfite liquors.

Acknowledgment

Several firms have made generous contributions which enabled the studies made to be undertaken. Especial thanks are extended to the Bausch and Lomb Optical Co., Rochester, N. Y.; the Beckman Instruments Inc., Fullerton, Calif.; the Minneapolis-Honeywell Co. Inc., Philadelphia, Pa., and the Vulcan Copper and Supply Co., Cincinnati, Ohio.

LITERATURE CITED

1. Anonymous. Feeding Apparatus for Wort. Pamphlet E 4. Svenska Jästfabriks AB, Stockholm, Sweden (1955).
2. Bates, F. J., *et al.* Polarimetry, Saccharimetry and the Sugars. Circular of the National Bureau of Standards C 440, Washington, D. C. (1942).
3. Bausch and Lomb Optical Co. *Control Refractometer Reference Manual.* Rochester, New York. (1955).
4. Frey, C. N. (Private communication, 1955).
5. Fuld, G. J. (Unpublished work, 1956).
6. Fuld, G. J., and Dunn, C. G. New process control applications in fermentation. Presented before the 130th Annual Meeting of the American Chemical Society. Sept. 1956.
7. Hayduck, F. Low Alcohol Yeast Process. U. S. Patent 1, 449, 114, March 20, 1923.
8. Holzbock, W. G. *Instruments for Measurement and Control.* Reinhold Publishing Co., New York (1955).
9. Lowry, O. H., and Lopez, J. A. The determination of inorganic phosphate in the presence of labile phosphate esters. *J. Biol. Chem.*, **162**, 421 (1946).
10. Neish, A. C. Analytical Methods for Bacterial Fermentations. Report No. 48-8-3 N. R. C. 2952 November 25, 1952. Saskatoon, Saskatchewan.
11. Olsen, B. H., and Johnson, M. J. Factors producing high yeast yields in synthetic media. *J. Bact.*, **57**, 235 (1949).
12. Peppler, H. J. (Private communication, 1955).
13. Sullivan, J. T. Guide to Carbohydrate Analysis of Forage Plants. Agricultural Research Service. U.S.D.A. University Park, Pa. (circa 1953).
14. White, J. The principle and practice of yeast production. LV. *American Brewer*, **82**, 32 (September 1949).
15. White, J. *Yeast Technology.* 1954, John Wiley, New York.
16. Wiley, A. J. (Private communication, 1955).

Effect of Tomato Cell Structures on Consistency of Tomato Juice[a]

R. T. Whittenberger and G. C. Nutting
Eastern Regional Research Laboratory,[b] Philadelphia 18, Pennsylvania

(Manuscript received July 19, 1956)

THE CONSISTENCY OF TOMATO JUICE depends partly on its chemical composition and partly on its physical structure. Although rather extensive research has been carried out on the chemical constituents, particularly on the pectic substances *(1, 3, 4, 6, 7, 8, 9,* and others*)*, relatively little attention has been given to the structural aspects of consistency *(2, 4, 5, 8, 10)*. The recent work of Hand *et al. (2)* shows that the influence of the insoluble structures on consistency may be much greater than has heretofore been recognized.

Composition and structure are, of course, closely interrelated. Although the insoluble structures may be the building blocks of a juice and may be required for the attainment of an acceptable degree of consistency, their properties and behavior are modified significantly by the presence of pectic substances. In the present study particular emphasis is given to defining the role of the microscopic structures in tomato juice consistency and to showing some of the interrelationships between structure, composition, and consistency.

Structure of tomato flesh cell. To understand the structure of tomato juice, it is helpful to observe the structure of a fresh tomato. A tomato is composed principally of relatively large, near-spherical flesh cells (Figure 1) which are filled with dilute sugar water or cell sap and small quantities of living matter and insoluble granules. The largest cells can barely be seen with the unaided eye. They may be visible as small gelatinous spots as tomato juice drains down the sides of a tumbler. The outer boundary or wall of the cells consists of interwoven cellulose fibrils impregnated with pectic compounds. The walls, although so thin as to be fragile, give mechanical stability to the cells and serve as a supporting framework for tissues. The great intrinsic strength of cellulose as fibers, threads, and fabrics is well known. Pectins are amorphous and, especially when swollen with water or cell sap, have little mechanical strength.

Cells in a tomato are joined by a pectic adhesive which softens as the tomato ripens and permits the cells to separate easily from each other. When the tomato is crushed to make juice, cells separate, sap is released, and cell walls often become broken and distorted. The simple separation of cells from the tissue brings about a very great reduction in viscosity. The cell walls, although separate, remain capable of exerting an important and even predominating influence on juice consistency despite the fact that they amount to a percent or less by weight.

[a] Presented at the Fifteenth Annual Meeting of the Institute of Food Technologists, Columbus, Ohio, June 14, 1955.

[b] One of the laboratories of the Eastern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

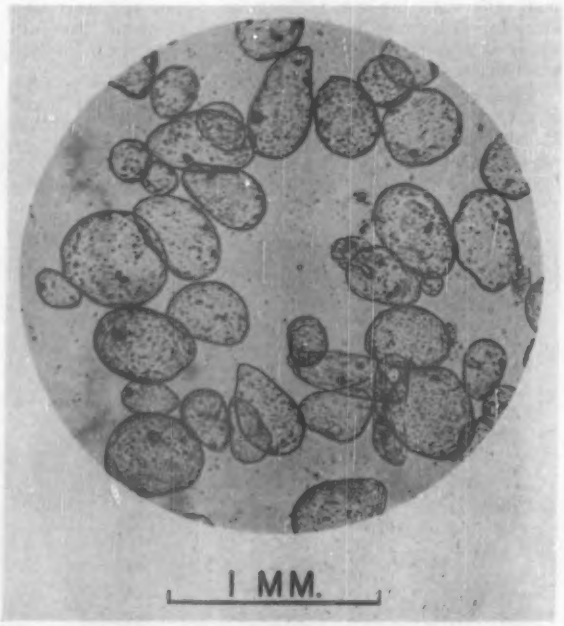


Figure 1. Unstained, living flesh cells from the center of a tomato. Insoluble granules and cell walls are seen.

OBSERVATIONS

Juices from dissected tomatoes. Tomatoes were dissected into the 4 fractions shown in Figure 2: A, the outer rind or shell of the tomato; B, the placenta or center tissues; C, the free juice occurring in the vicinity of the seeds; and D, the gelatinous envelopes surrounding the seeds (Figure 3). With tomatoes averaging 110 g. in weight, fraction A comprised the greatest proportion (48%) of the whole tomatoes (Table 1) and fraction D the smallest (8%).

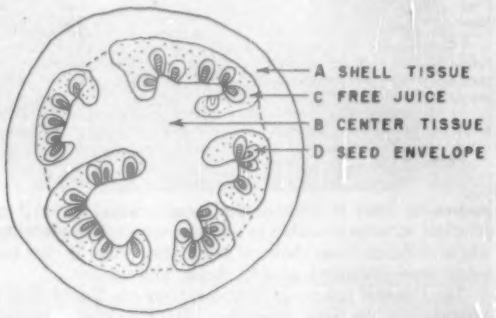


Figure 2. Cross section of a tomato. Tissues separated by dissection are indicated.

Tissues comprising the fractions were converted to juices by being heated to 190° F. and passed through a small Sepra Sieve (a tapered screw-type extractor). Consistency of the juices was measured with a Brookfield viscometer in a manner described by Hand *et al. (2)*, and the viscosity of serums (tomato juice freed from suspended particles) was determined in an Ostwald viscometer. Most photomicrographs of the diluted (1:1) juices were taken with the aid of polarized light and crossed Polaroids and a mounting chamber which gave a

Figure 3. Longitudinal section of tomato seed. The outer tissue is the seed envelope, the broad white band comprises the seed coat and seed hairs, and the central dark region is the seed proper. The envelope is folded in part.

uniform film of juice 350 microns thick. Under these conditions only crystalline structures, which in tomatoes are composed principally of cellulose, were brightly visible.

Large differences in the properties and structure of the juices were observed (Table 1). The thickest juice which was 432 apparent centitpoises (cp.), was obtained from the seed envelopes (fraction D). The serum viscosity of this juice also was extremely high (25.6 cp.), indicating the presence of relatively large amounts of undegraded pectic materials. This viscosity was about ten times as high as that of the thickest serum of the commercially available juices studied. During commercial juice manufacture, these pectin-rich envelopes usually, although not always, are stripped from the seeds and are included in the body of the juice. Enzymatic digestion of the

TABLE 1

Properties of juices from different fractions of tomatoes

Fraction of tomato	Juice	Percent of tomato	Consistency of juices, apparent cp.[1]		Viscosity of serum, cp.
			Original	Homogenized	
Shell	A	48	155	405	2.6
Center	B	26	145	335	2.4
Free juice	C	18	11[2]	15[2]	1.3
Envelopes	D	8	432	700[3]	25.6

[1] Recognizing the strong dependence of the viscosity of most tomato juices on the rate of shear, "Brookfield viscosities" of whole juices are throughout the paper designated "consistency" and expressed as "apparent centipoises."

[2] Low viscosities cannot be determined accurately under the measurement conditions used throughout (usually No. 2 rotor, 60 r.p.m.). Indicated viscosity of water was 4 cp. (actually, 1 cp.).

[3] Rotor No. 3 at 60 r.p.m. was used.

pectins in juice D lowered the serum viscosity to 1.2 cp. The principal structures visible in the juice were cell walls (Figure 4). These differed from those of most other cells in the tomato in being more elongated, pliable, elastic, and thinner.

The thinnest juice was obtained from the liquid (fraction C) surrounding the seed envelopes. Its Brookfield viscosity was only 11 apparent cp. and its serum viscosity was 1.3 cp. (see Table 1 footnotes). No structures were visible microscopically under polarized light, although numerous insoluble colored granules could be seen under ordinary illumination. The absence of cell walls from this juice was highly significant.

Juices made from the shell (A) and center (B) tissues were similar and resembled an average commercial tomato juice in properties and appearance. These juices comprised about 75% of the total juice from the dissected tomatoes. Juice A had a consistency of 155 apparent cp. and a serum viscosity of 2.6 cp. Quantities of cell walls were visible under the microscope (Figure 5).

Figure 4. Cell walls in juice from tomato seed envelopes. The walls contained much pectin and the juice was thick.

Consistency of the juices was increased by changing the structure of the insoluble constituents. This was accomplished by treating the juices in a Waring blender, a process analogous to homogenization. The increases were not equal in magnitude but varied with the nature of the insoluble components. Thus juices that contained quantities of cell walls (juices A, B, D) showed large increases, whereas juice C which contained numerous insoluble granules but not cell walls, was scarcely affected. Viscosity of the serums remained almost constant during the blender treatment, thus indicating that no more pectins were extracted or made soluble by homogenization.

Increase in consistency of juices A, B, and D was associated with the conversion of spherical particles to elongated particles and with a reduction in particle size. A comparison of Figures 5 and 6 shows the structural changes in the cell walls of juice A caused by homogenization.

Effect of maturity and preheat treatment. The character and quantity of insoluble structures in tomato juices depended partly on the maturity of tomatoes and on whether the tomatoes were heated before crushing. When hard, green, unheated tomatoes were made into juice (cold break method), relatively few cell walls were incorporated in the juice (Figure 7). The flesh cells stuck together in irregular clumps and most were discarded with the seeds and skins by the extractor. The juice consisted principally of expressed cell sap and small insoluble granules. It was relatively thin (Table 2).

Heating similar whole green tomatoes to a center temperature of 190° F. in a pressure cooker prior to their passage through the extractor (hot break method), resulted in the inclusion of quantities of cell walls in the juice (Figure 8). The heat not only softened the tissues and permitted easy separation

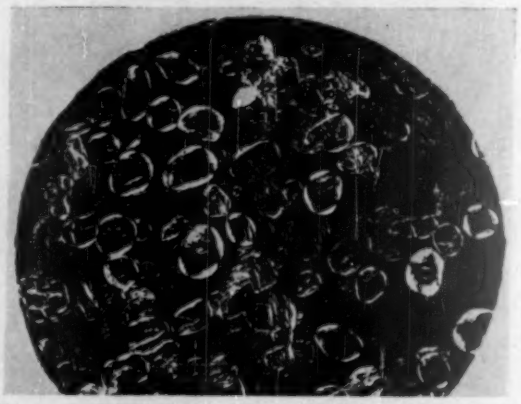


Figure 5. Spherical cell walls in juice from the outer shell of a tomato. Juice was average in consistency.

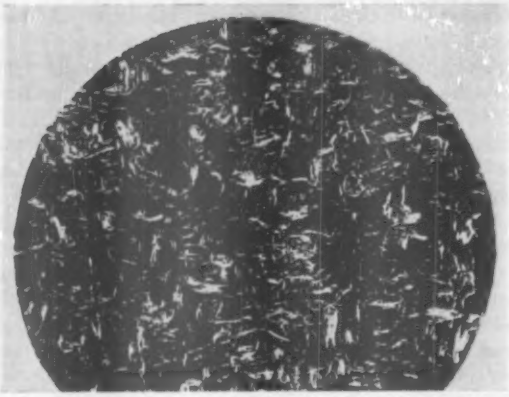


Figure 6. Same juice as in Figure 5 after homogenization in a Waring blender. Increase in linearity of cell walls is evident. Juice was thick.

of cells, but it also preserved the native pectins of the tomatoes. Although the serum viscosity (7.0 cp.) was several fold greater than that of an average commercial hot-break juice, it was insignificantly small in comparison with the viscosity of the whole juice (410 cp.). The juice was exceedingly thick, approximating the consistency of tomato puree.

With ripe tomatoes, differences in preheat treatment made relatively small differences in the amount and shape of cell walls in the resulting juice, although differences in the character of the walls did occur. Both preheated and not preheated whole tomatoes gave juices containing cell walls in quantity. In a ripe tomato the flesh cells were easily separable even without a preheat treatment. The hot break juice, however, was thicker than the cold break juice and contained more pectic materials, as indicated by the viscosity of its serum (3.1 cp.). When pectic materials made up a substantial part of the cell walls, the walls were relatively tacky, strong, and hydrophilic. Both juices were thicker than that from cold break green tomatoes, although neither of the juices was as thick as that from hot break green tomatoes.

TABLE 2

Effect of maturity and preheat treatment of tomatoes on consistency of tomato juice

Maturity of tomatoes	Preheat treatment	Consistency of juice, apparent cp.,	Viscosity of serum, cp.
Ripe	None	90	1.3
Ripe	190° F.	160	3.1
Green	None	55	1.9
Green	190° F.	410	7.0

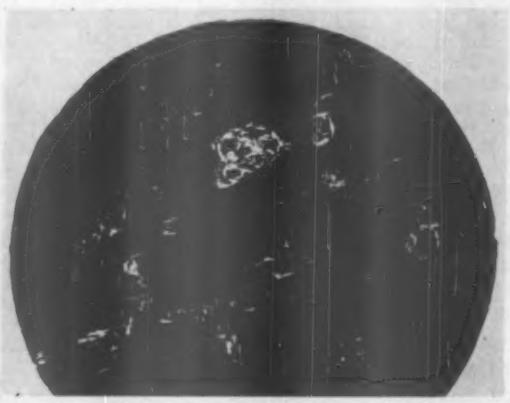


Figure 7. Relatively few cell walls were present in the juice from unheated green tomatoes. Juice was thin.

Effects of pectinase and cellulase. Removal of pectin from serum and cell walls in a hot break juice by pectinase caused a significant decrease in consistency (Table 3). This decrease was not accompanied by a conspicuous change in the microscopic appearance of cell walls, although the walls did appear to increase slightly in birefringence. Chemical analyses confirmed the elimination of pectins from both the cell walls and the serum. However, consistency of the pectin-free juice was restored and even made to exceed its original value by changing the structure, i.e., by decreasing the size and increasing the linearity of the residual cellulosic walls in a Waring blender. The blender caused greater splintering of the pectin-free walls than it did of pectin-impregnated walls, thus indicating the change in cell wall character brought about by the removal of pectins. Maximum consistency was obtained by treating the original pectin-containing juice in the blender. Evidently the combined effects of dissolved pectin in raising the serum viscosity and of insoluble pectin in raising the water-holding capacity of the fragmented cell walls more than offset the greater wall fragmentation in the pectin-free juice.

TABLE 3

Effect of pectinase and cellulase on the consistency of tomato juice

Treatment	Consistency of juice, apparent cp.		Viscosity of serum, cp.
	Original	Homogenized after treatment	
None	131	224	2.3
Pectinase	83	163	1.1
Cellulase (containing pectinase)	58	54	1.1

Unfortunately, cellulose-digesting enzymes were not available in pure form. The enzyme preparation used digested pectic substances as well as cellulose. Treatment of the original juice with the preparation lowered consistency appreciably. Essentially all pectic substances were digested, as indicated by the drop in serum viscosity, and the bulk of the cellulose was digested, as indicated by microscopical examination. Only a small number of fragments of the cellulosic walls were visible and these had lost their birefringence. There was no change in the appearance of the insoluble granules.

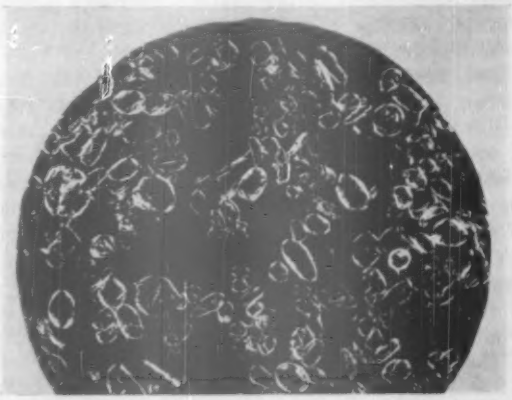


Figure 8. Preheated green tomatoes gave a thick juice containing many cell walls.

With the digestion of the major portion of cellulose, consistency of the juice was not restored by homogenization. Although incompletely digested fragments of cellulose were present in sufficient amount to maintain consistency at about 50 cp., the fragments evidently were too small to be affected by the homogenization treatment, just as colloidal molecules of pectin in solution are unaffected. As shown previously, homoge-

nization has almost no effect on consistency of the insoluble granules. The results indicated, therefore, the importance of cellulosic structures both in maintaining consistency and in increasing consistency through homogenization.

DISCUSSION

New evidence is presented showing the importance of physical structure in the consistency of tomato juice. Specifically, plant cell walls are identified as the principal structural elements, or building blocks, of a juice. Without these building blocks, the consistency is trivial. Consistency depends largely on the quantity, shape, degree of subdivison, and character of the cell walls present.

Several factors influence the quantity of cell walls in a juice. Among these are maturity of tomatoes, native differences in cell wall thickness, type of preheat treatment of fresh fruit, and manner of extracting or comminuting tomatoes to form juice. These factors are closely interrelated, and often variations in one factor can be compensated for by adjustments in another. Data in a previous section of this paper and elsewhere *(2, 10)* indicate how some of these adjustments may be made.

Although two juices may contain identical quantities of cell walls, they may differ in consistency because of differences in the configuration, or structural arrangement, of the walls. In general, sheetlike or rodlike walls or wall fragments offer more resistance to flow and give a more stable juice structure than do spherical walls. The irregularity of cell wall form depends largely on the mechanical treatment the walls receive during juice manufacture. Forcing cell walls through passages of small clearance, and other types of shearing, stirring or beating actions increase linearity.

The character of cell walls varies with their pectin content. Walls permeated with pectins are tacky, resilient, and capable of binding appreciable quantities of water, whereas walls devoid of pectins are brittle, friable, and less hydrophilic. Under similar conditions, the pectin-containing walls yield the thicker juices. Many of the same factors that control the cell wall content of a juice also control its pectin content. It is well known that the native pectins of tomatoes may be preserved during juice manufacture by a suitable preheat treatment.

These studies are being continued.

SUMMARY

Microscopic studies showed that the principal structural element in tomato juice is the flesh cell. Of the insoluble structures in the flesh cell, the cell wall was identified as the structure most closely related to consistency.

Tomatoes were dissected into four separate tissue fractions which were converted to juices. Juices from the outer shell and from the center tissues were moderately thick and contained moderate quantities of cell walls. Free juice from the seed cavities was exceedingly thin and was devoid of cell walls. Juice from the gelatinous seed envelopes was thick, and contained cell walls heavily impregnated with pectin. The juices containing cell walls were thickened by increasing the linearity and surface area of the walls through homogenization or equivalent mechanical treatment.

Maturity of tomatoes and preheat treatment affected juice structure, composition, and consistency. Unheated green tomatoes gave a juice low in consistency and cell wall content, and moderately low in pectin content. Whole green tomatoes preheated to 190° F. yielded a juice high in consistency, cell wall content, and pectin content. With ripe tomatoes differences in preheat treatment made smaller differences in juice structure and pectin content. The differences in consistency, however, were great enough to be of practical significance. Although enzymatic digestion of pectin in a juice lowered consistency, consistency was restored by mechanically changing the structure of the pectin-free cell walls. Partial enzymatic digestion of cellulose in the cell walls irreversibly lowered consistency. Maximum consistency was obtained when both cell walls and pectins were present in quantity. It was concluded that consistency depends largely on the quantity, shape, and degree of subdivision of the cell walls present, and on the character of the walls as determined by the occurrence of pectins.

LITERATURE CITED

1. Bigelow, W. D., Smith, H. R., and Greenleaf, C. A. Tomato Products. *Bulletin 27-L*, Revised, National Canners Association (1950).
2. Hand, D. B., Moyer, J. C., Ransford, J. R., Hening, J. C., and Whittenberger, R. T. Effect of processing conditions on the viscosity of tomato juice. *Food Technol.*, **9**, 228 (1955).
3. Kertesz, Z. I. *The Pectic Substances.* Interscience Publishers, Inc., New York (1951).
4. Kertesz, Z. I., and Loconti, J. D. Factors Determining the Consistency of Commercial Canned Tomato Juice. New York State Agr. Exp. Sta., *Tech. Bull. 272* (1944).
5. Kimball, L. B., and Kertesz, Z. I. Practical determination of size distribution of suspended particles in macerated tomato products. *Food Technol.*, **6**, 68 (1952).
6. Luh, B. S., Leonard, S., and Dempsey, W. Pectic substances of Pearson and San Marzano tomatoes. *Food Research*, **19**, 146 (1954).
7. McColloch, R. J., and Kertesz, Z. I. Recent developments of practical significance in the field of pectic enzymes. *Food Technol.*, **3**, 94 (1949).
8. McColloch, R. J., Nielsen, B. W., and Beavens, E. A. Factors influencing the quality of tomato paste. II. Pectic changes during processing. *Food Technol.*, **4**, 339 (1950).
9. McColloch, R. J., Keller, G. J., and Beavens, E. A. Factors influencing the quality of tomato products. I. Surface-localized pectic enzymes inactivated by blanching. *Food Technol.*, **6**, 197 (1952).
10. Robinson, W. B., Kimball, L. B., Ransford, J. R., Moyer, J. C., and Hand, D. B. Factors influencing the degree of settling in tomato juice. *Food Technol.*, **10**, 109 (1956).

Current Refrigeration Problems of Interest to the Citrus Industry[a]

Daniel C. McCoy
Consulting Engineer, 7546 Normandy Lane, Dayton 9, Ohio

(Manuscript received June 13, 1956)

DURING THE PAST DECADE, the necessity for the "team" approach to research and application—where the user and the food technologist, refrigeration engineer, and other scientists work together for the solution of technological problems—has been impressed upon all of us. Gone are the days of the "inventor" of a technique or a machine.

In the 1955 Report of The Refrigeration Research Foundation, Dr. Diehl, its Director, comments: "Most effective emphasis and achievement of objectives are obtained by constructive collaboration, which the complexity of modern technology makes compulsory. The technical leadership which results from such joint counsel and action is markedly more effective than individual effort could be."

Mr. Harold E. Pinches, Assistant Director, Farm and Land Management Research, the U. S. Department of Agriculture, in his address to the Agricultural Engineers at the 3rd Annual Engineering Conference, 4 May 1956 at Ohio State University stated: "We need, I believe, to get away from too severe compartmentation of our thinking. We must cross the lines between the conventional divisions of our profession."

Numerous other examples of similar thinking could be cited. This brings us to the purpose of this paper; namely, to call attention to some problems in the use of refrigeration, the solution of which by known techniques can be valuable to the citrus industry. But they need the team approach to bring them into accepted practice and thus to realize maximum benefits.

Most foods should be cooled immediately after they are harvested, and then held under refrigeration until the housewife takes them from her household refrigerator to prepare them for the table. Thirty years ago, when I first entered the refrigeration business, there were many gaps in this chain of protection. One by one these gaps have been closed. If not yet embodied in currently accepted commercial practice, at least the fundamental research has been completed and the *why* and *how* technique is available. It now remains for public demand for better foods to force acceptance of these techniques, for the economics of their application to justify them—and evolution will bring them into use. This paper will consider two relatively new refrigeration applications which are technically sound, and which should be kept constantly in mind in your future planning.

Pre-cooling. The first is pre-cooling of fruits and vegetables as soon as possible after harvesting. This has its scientific foundation in the chemical law that increase of temperature speeds completion of chemical reactions, and, conversely, that reduction of temperature slows reactions. Loss of quality of food and its eventual destruction are both subject to this law. The destructive processes are chemical, enzymatic, and bacteriological. All take place at accelerated rates with increase of temperature.

Time is also a related factor—the longer the time, the greater the deterioration, even at reduced temperatures. Lapse of time is inevitable even in the orderly marketing process for foods; hence, the maximum advantages of refrigeration should be employed to offset the ravages of time.

Vacuum cooling. Two types of pre-cooling have been successfully developed; namely, vacuum and hydro-cooling. The vacuum process does the best job on those products which have a large exposed surface in relation to their mass or volume, for example on lettuce. A large percentage of the lettuce shipped from the western states is now vacuum pre-cooled prior to loading for shipment, with benefits to all concerned, from producer to consumer *(5)*. At present, however, this method seems of little value to the citrus industry.

Hydro-cooling. This process has proved applicable to various fruits and vegetables but is best adapted to citrus products. Using water as a transfer medium to reduce the temperature of the product, a very high rate of heat removal can be obtained, particularly if the water is sprayed over the cooling product, and the warmed water is then circulated rapidly over some cooling medium to remove the heat before recirculation. If the technique is to be successful, the product must be exposed to the cooling water for the proper length of time to reduce it to the required temperature. Moreover, there must be sufficient cooling capacity in the form of ice or mechanical refrigeration to dispose of this heat.

As the process is currently applied, the product moves through the sprayed cold water on a conveyor belt, the speed of which can be regulated to expose the product to the cooling water for the correct length of time. The water can be chemically treated to inhibit micro-organisms which attack the fruit and eventually reduce its quality *(3, 4, 10)*. The equipment can even be mounted on a truck-trailer combination and taken directly into the field where harvest is in progress, thus materially reducing product handling (Figure 1).

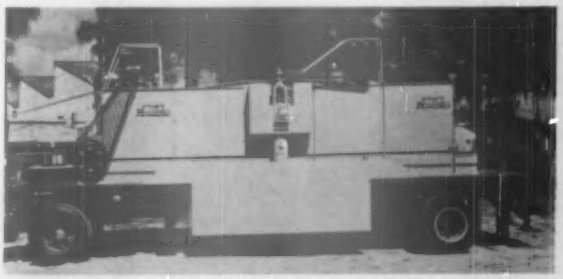


Figure 1. Portable Hydro cooler mounted on trailer. May be moved from one harvest point to another.

Value of this process lies in properly preparing citrus and other fruits and vegetables for transport to offset some of the known limitations of in-transit refrigeration. For example, a study of overseas shipping by the U.S.D.A. *(1)* indicates that better quality products could be marketed in Europe if the following practices were observed:

1. Select and pack higher quality fruit for export.
2. Pre-cool oranges to below 40° F. as rapidly as possible after packing and protect them from warming on the dock or while loading.
3. Maintain transit temperature of about 35° F. for oranges and 50° to 55° F. for grapefruit.

Shipping tests showed that the temperature of much of the fruit was too high when loaded. Some of it was loaded at temperatures as high as 90° F. Also, it is reported, the ships did not have sufficient refrigeration capacity to lower it rapidly to a suitable transit temperature. The oranges loaded at 90° F. cooled only to 41° to 59° F. during the voyage—hardly the optimum requirement.

It is common knowledge to those well versed in the field of mobile refrigeration, that most mobile applications have been made on the basis of *storing* the product only. The refrigeration capacity provided has been sized to take care of only the heat which leaks through the insulated walls of the space being cooled, with no provision being made to remove the sensible heat from the product or control the heat of respiration after loading. The occasional success attained with such installations has been invariably co-incidental with unusually favorable conditions rarely encountered in day-to-day practice, and certainly never encountered in summer weather when protection is most needed.

Here is an ideal example of where the team approach in determining proper technique by research, followed by putting that technique into practice, can be used. In the research phase, *the horticulturist* and *food technologist* find the optimum conditions for maximum product life, *the bacteriologist* provides the knowledge for micro-organism control, the *packaging engineer* works out the packaging technique best suited to the application, the *mechanical engineer* designs the physical equipment required, the *refrigeration engineer* applies the right capacity and type of refrigeration, and the *chemist* provides chemical treatment to control the micro-organisms. In the application phase, using these techniques and proper equipment, the *grower, shipper, car lines, truck lines, railroads* and finally the *steamship companies* put them to use. However, each must do his part. If at any place in the chain we have a weak link, the technique bogs down and we end up with less than the optimum results which the research shows is possible.

Mechanically refrigerated railroad cars. The second refrigeration application I wish to stress concerns the *mechanically refrigerated railroad refrigerator car.* Today's successful mechanical car *(6, 9)* owes its development to the impetus which your industry put behind it when it was found that iced cars left much to be desired in handling one of your major sources of income; namely, frozen orange juice concentrate. Unfortunately, there are still not enough mechanical cars to handle the huge frozen concentrate business, let alone the general frozen food business. However, the mechanical car and techniques associated with it deserve your constant thought in future planning because it is thoroughly sound. It is destined to be of increased importance in the future.

The mechanical car offers *controlled temperature* regardless of ambient weather conditions. The latest mechanically cooled cars are capable of automatically maintaining controlled temperature through a range of minus 10° F. to plus 70° F. Ambient conditions will determine if cooling or heating should be applied. The equipment will automatically switch from the one to the other as conditions dictate. Thus, we have automatically controlled product protection from summer heat by cooling, and protection against winter freezing by automatic heating.

Most mechanical cars in use today are distinguishable from the iced car by the louvred compartment at one end of the car (Figure 2). This holds the power and

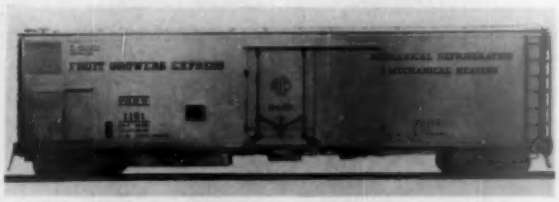


Figure 2. Current Mechanical Refrigerator Car. The first of these was placed in service February 1949. Fruit Growers Express and associated companies has 900 now in service and 380 being built.

refrigeration machinery. Below the car will be seen large Diesel fuel tanks, carrying enough fuel to operate the refrigeration system for about 18 days. Many improvements in car construction have been incorporated into these modern cars, including substantial improvement in insulation—something which has long been needed. These improvements provide better service to the user and deliver the load to the consumer in better condition. Due to lack of proper insulation, most of the old ice cars are not suited to the application of mechanical refrigeration. Another type of mechanical refrigerator car application recently introduced uses "drop in" refrigeration units, installed where the icing hatches used to be. A Diesel-alternator power unit is installed under the car along with the fuel tanks.

The mechanical car is another development that has resulted from the team approach to a technical problem. Its success rests on the team efforts of users, car builders, railroads, refrigeration engineers, Diesel engine engineers, and electric and generator and motor engineers. The Fruit Growers' Express Company and its associated companies, and the Delco, Detroit Diesel and Frigidaire Divisions of General Motors Corporation played the major role in this development. The citrus industry has benefited from the development and stands to benefit further in the future.

Hydro-cooling prior to loading, combined with the controlled in-transit temperature provided by the car, offers a complete solution to the problems uncovered in the U.S.D.A. investigations *(1)* previously cited. With both pre-cooling and the mechanical car, the shipments would have arrived shipside at the proper temperature. The investigation further showed that some of the fruit suffered after shipside arrival due to lack of icing to maintain refrigeration while the fruit was waitng to be loaded. The mechanically refrigerated car would have held the fruit at the proper temperature without further attention until it could have been loaded.

The combinatioin of pre-cooling and the mechanical car deserves particular emphasis. The car has limitations, being a mobile application. These same limitations apply to refrigerated trucks. Such equipment is designed to *maintain* temperature and *not* to remove sensible heat and heat of respiration from hot products. To provide refrigeration capacity in mobile equipment sufficient to accomplish the pre-cooling job is not practical. It involves too much additional non-revenue weight, and such equipment would take up too much space. The amount of heat that has to be removed from a hot carload or truckload of fruit or vegetables to reach optimum in-transit or long time storage temperatures may amount to 10 times that involved when the equipment has to handle only the heat which leaks through the walls of the truck or car, and to hold only that temperature required for pre-cooled products *(6)*. The enormous load of precooling is better delegated to stationary pre-cooling equipment rather than saddled on mobile equipment. The combination of hydro-cooling and the mechanically refrigerated car should be constantly in mind in your future planning.

Refrigeration in the retail store. Now let us turn to a third field of refrigeration application of interest to the citrus industry; namely, *low temperature refrigeration in the retail store.* This is the point of contact between you and the ultimate consumer of your products. Your most valuable source of income, frozen juice concentrates, can be made or broken here depending on how well the products are handled in this segment of the distribution process. There is a need, by the way, for a team approach to solve some problems now existing at this level.

A case study. In March and April of 1953 I made a trip to the West Coast. At every stop, going and returning, I visited retail stores to observe frozen food handling practices and equipment. In the large number of stores visited, I found only two open type low temperature merchandising display cases where the frozen products were in satisfactory condition. During the whole trip the weather was mild—a top coat was comfortable all the time. I shudder to think of the quality of frozen foods dispensed from these places in hot summer weather. Continued observation since brings me to conclude that there has been some (but not enough) improvement. These personal observations are confirmed by a recent survey *(11)*.

This survey indicates that the consumer is alert to the situation as shown by the following quotations from the report:

1. "The average consumer in this sample was more interested in buying frozen foods and ice cream which were kept under proper refrigeration than in any other factor."
2. "About one respondent out of each seven contacted in this survey has made at least one unsatisfactory purchase of a frozen food item—12.5% have been juices."
3. "Percentages of dissatisfaction attributable to causes controllable by dealer were:

Spoiled	20.8%
Stale	5.6%
Too old	11.1%
Thawed and refrozen	8.3%
Total	45.8%"

4. "Percentages of dissatisfaction not directly attributable to either manufacturer or dealer individually, but for which joint responsibility should be accepted:

Discolored products	6.9%
Soft, mush products	6.9%
Unpleasant taste	16.7%
Total	30.5%

It would appear that both manufacturers and dealers need to tighten up on inspection of the finished product, storage and handling, and maintenance of fresh stocks of merchandise."

5. "One out of five indicated dissatisfaction with handling of frozen foods; this is still too high a proportion for a healthy growth of frozen food consumption in this market."
6. Of the respondents, 69.4% commented on "sloppy, jumbled display, making it hard for the customer to find the item wanted without digging to the bottom of pile."
7. "Display space too crowded" and "improper refrigeration" were stressed by 2.8% and 6.5%, respectively.

These observations show unmistakably the need for the application of corrective measures.

The fundamental fact that frozen juice concentrates should be held at 0° F. or below, should be kept constantly in mind at all stages of the distributive process. This applies to all frozen foods. Let us follow frozen foods through the retail store, assuming that they have been delivered in good condition at 0° F. or below and see where and how we are getting into trouble when this temperature is not maintained.

Trouble can start immediately after the food has been delivered by not getting it under zero F. refrigeration at once. I have seen frozen foods delivered at 8:00 in the morning and left standing at room temperature all day. Finally, at closing time, they were moved into a 35° F. meat cooler. All of this food was subsequently loaded into the low temperature display cases. For

future reference let us call this Problem Number 1. What is wrong here?

These are the answers.

1. Lack of knowledge by the store personnel of the refrigeration requirements for frozen foods.
2. Lack of supervision of lower echelons of personnel, and, too often, supervision no better informed.
3. Lack of proper type of and/or adequate capacity for bulk storage of frozen foods.
4. Attempting to refreeze frozen foods (either knowingly or unknowingly) in display cases.

Now, with the food in the merchandising display case—let us call this Problem Number 2—what do we find wrong here? The answers are:

1. The cases may or may not be at 0° F. or lower.
2. The case may be stocked with such a volume of frozen food, due to overemphasis of mass display, that a sizable portion of the food is out of the refrigerated zone of the case.
3. After the store has been open several hours, the stock of frozen foods in the case is so jumbled, due to customer handling, that it is a major "digging" operation to locate what is wanted. Many customers turn away in disgust and do not buy.

How can these problems be corrected? Starting with Problem No. 1, items 1 and 2, lack of knowledge: Consult the literature; there is a vast amount of technical information available on frozen foods. Sufficient of this has been reduced to layman's language to correct the existing lack of knowledge in lower and higher echelons of store personnel; if an educational campaign were organized and sufficient time and follow-up put on it, it would really accomplish the job. In all fields, the lack of knowledge of merchandise and products at the retail level is appalling. We need a revival of old time specialty selling methods and sales training. The complexity of today's supermarket puts the manager and his supervisory personnel in the category of running a three-ring circus. We need more specialized training for the retail clerks who are in direct contact with the customers and also of the supervisory personnel.

Now as to lack of proper and adequate storage—I am going to draw an analogy to an old and common retail food store operation which lights the way for the solution of this problem; namely, the retail meat market. No operator of a retail meat department doing any sizable business would attempt to operate without a walk-in cooler to store bulk meat backing up his refrigerated display case. The trade papers have been bemoaning the lack of 0° F. refrigerated merchandising display cases to handle frozen foods in the retail store. Why not make better use of the cases already there in the way they were intended to be used? Why not place the bulk storage in less valuable space in the rear of the store using less expensive equipment? Zero degree F. walk-in coolers for larger stores and reach-in refrigerators for the smaller stores, located in the rear of the store, are a solution to this problem.

Display cases were designed to display and sell merchandise—not for bulk storage. I firmly believe that with adequate bulk storage in the rear and frequent restocking of cases therefrom, some of the lack of sales space believed to exist will be compensated for. Adequate back store storage will also solve the problem of where to put deliveries of frozen foods upon arrival instead of letting them sit out, or trying to store them in 35° F. meat or produce coolers.

There is no known rule for computing the storage volume required that will apply to all stores. Too many factors will influence this. As a starter, where operational experience is not available, I would suggest a minimum of 4 to 5 cubic feet of usable bulk storage volume for each cubic foot of display space. Additional space equivalent to the volume of the largest display case in the store should also be provided as a reserve to store products should a display case break down. Its products can thus be protected by moving them into bulk storage until repairs are made.

Turning now to Problem 1, item 4, refreezing in display cases—the physical limitations imposed on application of refrigerating equipment to display cases of all types confines them to providing refrigeration for holding of already cooled products *(7, 8)*. These limitations are like unto those of mobile equipment previously discussed. This subject is far too complex and lengthy to go into any detail here. Suffice it to say that no refrigerated merchandising display case should ever be called on to do a product cooling job, much less a product freezing or refreezing job. The best answer to this is not to let the products thaw out by improper handling prior to their being put into the display case, and to maintain the cases at temperatures where they will not soften or thaw. This also calls for adequate supervision in the retail store.

Problem 2, item 1, proper case temperatures, will take us partially back into item 4 of Problem 1. There are many low-temperature open-display merchandising cases now available which are capable of maintaining correct preservation conditions for frozen foods if they are applied, and if they are operated, correctly *(7, 8)*. There are some rigid rules for proper installation of open type display cases which are too often violated. Correction of such misapplications is usually a difficult and expensive task. Their relation to heating and air conditioning in the store, the effects of lighting and relation to sunlight through windows, draughts from open doors, etc., must all be considered.

All of these cases require built-in provisions for automatic defrosting of their cooling units. In general, this defrosting is satisfactory for what it was intended to do if properly adjusted and maintained after installation. However, frosting will occur in other portions of these cases where it may not be visible and where defrosting the coils will not remove such frost (Figure 3). The only solution to this is regular, periodic unloading of the cases and shutdown for complete defrost. Most retailers object to this; some violently. But, until some method of circumventing it is available, there is no other solution. So, retailers have to become part of the

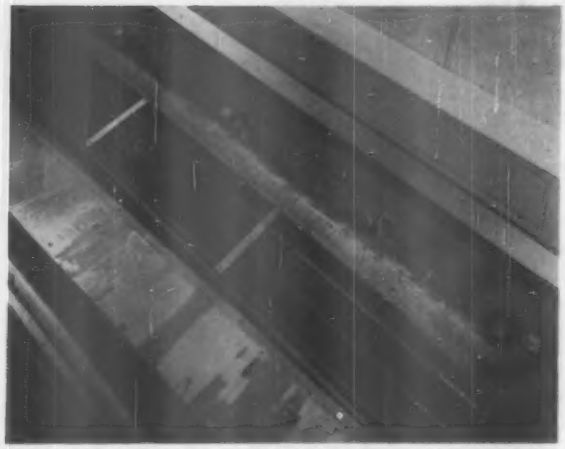


Figure 3. Hidden ice and frost formation in Low Temperature Display case.

team and to assume their responsibility to attain proper preservation of their display of frozen foods.

Item 2 of Problem 2, overstocking, goes back to the same solutions we have for items 1 and 2 of Problem 1. Knowledge of storage conditions for frozen foods is required and proper supervision to assure their being applied is essential. Most low temperature display cases being marketed today have the limits of the refrigerated zone very plainly marked in the case. There is no excuse for loading beyond this line. However, such practice is common, due to the zeal of the retailer for mass display. There is no denying that mass display sells merchandise. But when it sells merchandise which has been deteriorated because of lack of refrigeration, due to improper displays, repeat sales are bound to suffer. Again we have need for knowledge, supervision, and team work—with the retailer doing his share.

Item 3, confusion of the stock in the sales case, again comes back to supervision and is related to bulk storage facilities. Constant supervision of the products in the display cases, re-arranging them and replenishing them from bulk storage at frequent intervals, will solve this problem. Properly trained and well informed sales personnel, operating a frozen food department where food is properly handled, and the display kept orderly and attractive, will sell more products and create repeat sales.

One of the most vicious practices in retailing frozen foods is mass display without refrigeration. The retailer either does not know proper handling practice or is gambling on turning over his display before it thaws. Unfortunately, it usually does not turn over fast enough. This practice should be eliminated completely.

Proper and adequate low temperature refrigeration and proper handling of frozen foods at the retail level are a matter for concern by the citrus industry. The frozen food and ice cream industries should also be concerned as their products, too, are being mishandled. The commercial fixture industry and the refrigeration industry are also involved as their equipment often gets unjustly blamed because of the mishandling. So far, efforts at correction have not made too substantial progress, probably because they have been too infrequent and scattered.

SUMMARY

Hydro-cooling combined with mechanically refrigerated railroad cars and mechanically refrigerated trucks deserve attention in future planning by the citrus industry. The combination will improve the quality of citrus products delivered to the consumer.

Low temperature refrigeration and the handling of frozen foods in the retail store need improvement. Technical knowledge upon which to found improvement exists and should be applied. An educational campaign is suggested with all concerned combining in a mass attack to correct current mal-practices.

Acknowledgments

For photos used in slides and for figures in printed version—Food Machinery Corp., Florida Division, Lakeland, Fla.; Fruit Growers Express Co., Washington, D. C.; Frigidaire Divisions, General Motors Corp., Dayton, Ohio; Minute Maid Corp., Plymouth, Florida; C. Schmidt & Co., Cincinnati, Ohio; Birds-Eye Division, General Foods Corp., White Plains, New York.

For data not covered in "Literature Cited"—Dr. F. D. Gerwe, Food Machinery Corp., Lakeland, Florida; Mr. John Rill, President, Fruit Growers Express Co., Washington, D. C.

LITERATURE CITED

1. Cook, Harold T. Quality citrus fruits for European markets. *Marketing Activities*, U.S.D.A. Jan. (1956).
2. DuBois, C. W., and Kew, T. J. Storage temperature effects on frozen citrus concentrates. *Refrigerating Engineering*, **59**, 772 (1951).
3. Gerwe, R. D. Cool peaches mean cold profits. *American Fruit Grower*, July 14 (1953).
4. Gerwe, R. D., and Slade, M. A. Pre-cooling fruits and vegetables by means of the "Stericooler." Mimeograph, Food Machinery Corp., Lakeland, Florida (1953).
5. Hayes, H. P. Vacuum cooling of produce. *Refrigerating Engineering*, **62**, 47 (1954). See also an unsigned article: Giant chambers cool lettuce. *Refrigerating Engineering*, **63**, 70 (1955).
6. Henney, C. F., and McCoy, D. C. Mechanical refrigeration for railroad refrigerator cars. *Refrigerating Engineering*, **62**, 41 (1954).
7. McCoy, D. C. Commercial refrigerators. *Data Book*, Amer. Soc. of Ref. Engrs., Chapter 33 (1954-55).
8. McCoy, D. C. The open type refrigerated display case—a blessing or a curse? Mimeograph of Address to Mich. Dairy Mfgrs. Conference (1953). Copies available from the author.
9. Peck, C. B. Special report: mechanical refrigeration. *Railway Age*, **138**, 49 (1955).
10. Redit, W. H., and Smith, M. A. Precooling South Carolina Peaches. H. T. & S. Office Report, No. 306, U.S.D.A. (1953).
11. Semon, John, and Gawthrop, P. R. A survey of the Marietta, Ohio consumer market for frozen foods and ice cream. Mimeograph, Marietta College and Marietta Frozen Food Locker Co. (1955).

The Time-Temperature Tolerance of Frozen Foods. I. Introduction—The Problem and the Attack

W. B. Van Arsdel
Western Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Albany, California

(Manuscript received August 18, 1956)

Since 1948 the Western Utilization Research Branch has been engaged in a major investigation designed to find out how frozen food products behave under conditions of time and temperature such as they may encounter in the commercial distribution system. Derivative objectives include the suggestion of improvements in raw material, processing, and packaging which may become apparent upon analysis of these results, and the discovery or improvement of tests for product quality. This article, introducing a series which will present the results of the project, describes the problem that led to initiation of the work and outlines the general plan of attack. The investigations thus far have been concerned with a number of frozen fruit products, several vegetables, chickens and turkeys, and several pre-cooked frozen products.

The problem. By 1948, the year this project was initiated in the Western Utilization Research Branch, the frozen food industry had already achieved the stature of a young giant, although it was less than 20 years old as a significant factor in the distribution of food. Production had passed the billion-pound mark, and wholesale value of the products was in excess of $370 million. The frozen food display cabinet was becoming a familiar fixture in food markets throughout much of the Nation. Housewives, restaurants and hotels, institutions, and the Armed Services were buying frozen foods not as novelties or luxuries but as economical and convenient staples. The recently introduced frozen orange juice concentrate had been an immediate success and was evidently headed for great developments.

By 1948, however, industry leaders had become aware that the high quality potentials of frozen foods were not always being realized at the consumer level. Too many well justified complaints were being received. Serious deterioration of the color and flavor of some fruits and vegetables was being reported, and even mold or bacterial growth in some packages; in some cans of the new orange juice concentrate the contents had gelled or the cloud in the reconstituted juice settled rapidly. Claims for loss or damage were being encountered by distributors, warehousemen, and transportation companies. More serious in the long run than the immediate monetary losses was the probability that customers were being permanently lost. A bad experience with one package of frozen food was likely to prejudice a housewife against all frozen foods. Perceptible slackening of demand for some products was evidently the direct result of consumer dissatisfaction. As reported by Anderson *(2)*, 1947 had been a severe disappointment to the industry. The large carryover of unsold stocks was attributed in part to the presence of inferior products on the market.

Some of the difficulties had been traced to production problems such as raw material selection and handling, precise control of blanching of vegetables, prompt and careful handling, provision of satisfactory packaging, and the like. Extensive research had been and was being carried on in the effort to solve these problems. The techniques and organization of quality control in the packing plants were being perfected and more strictly applied.

But it was also known throughout the industry that, although many products were leaving the packing plants in excellent condition, too often they were grossly deteriorated by the time they were purchased in a retail market. Commercial distribution of these new food products, visualized by pioneers in the industry as a system unique in its degree of control of the distribution conditions, evidently was subject to some unexpected hazards.

What, in fact, are the specifications for a satisfactory distribution system? Such a system must not only be capable of maintaining the frozen products in excellent condition up to the point of delivery to the consumer, but also it must be economically feasible. Even before 1948 people in the frozen food industry had settled upon 0° F. or lower as the temperature to be maintained at all times. Humphrey *(7)* commented that the ideal system would be a refrigerated tunnel extending from the packing plant to the home freezing cabinet. However, he recognized that for the time being, at least, something short of ideal conditions would have to be accepted.

Our commercial distribution system for frozen foods in the United States is largely a creation of the past 20 years, even though each of its main links has evolved from well-established distribution facilities. Public refrigerated warehouses and their associated order assembly rooms have in many cases been built, or rebuilt, primarily to handle frozen foods. Railroad cars and highway trucks have been built or modified to maintain lower temperatures than are needed for the transportation of fresh produce. Refrigerated cabinets installed in modern markets are a far cry from the grocery store and butcher shop refrigerators of 25 years ago. The capital investment in specialized facilities amounts to many hundreds of millions of dollars. It was felt that better use of existing facilities might be made and dangerously careless practices eliminated if critical operations could be identified and tolerable variations from ideal conditions be determined. Radical modification of facilities might be undertaken throughout the industry, but only upon a strong showing of necessity.

During the years since 1948 many improvements in practice and large investments in improved equipment have, in fact, been made. Frozen food consumption has continued its phenomenal growth; total sales in 1955 are estimated to have been 4.5 billion pounds. Nevertheless, the problem recognized in 1948 remains a matter of deep concern to the industry. Too many justifiable complaints about poor quality are still being received.

The research job. Technical men in the industry and in research agencies dealing with frozen foods were aware that not enough factual basis existed for the

decisions that needed to be made both by various interests engaged in the production and distribution of frozen foods and by public health agencies. A comprehensive and conclusive research job was a necessary first step. The information needed fell into two distinct but interrelated fields of research:

(1) Comprehensive survey of the temperatures and times experienced by frozen foods in the distribution system, and

(2) Comprehensive determination of the behavior of commercially packed frozen foods with respect to quality changes, under at least as wide a range of times and temperature conditions as might be encountered in the distribution system.

The second of these fields is the general subject of the series of publications to which this is an introduction. We have come to refer to it as study of the "time-temperature tolerance of frozen foods," and sometimes, in short, as "the TTT project." The term "time-temperature tolerance" is perhaps not the best that could be devised to characterize the matters investigated, but it has attained wide currency, and does emphasize the dual importance of the time and temperature factors.

Limited surveys of the temperatures and times actually experienced by frozen foods were already under way in 1948. Pentzer *(11)*, Larson, Mixon, and Stokes *(8)*, and Harvey and Redit *(5)* have published records of temperatures of frozen foods during rail and truck transportation. The Association of American Railroads and the Pacific Fruit Express Co. were making numerous records of temperature and time during transcontinental rail shipment. Considerable information about warehouse temperatures was available. Until 1952 and 1953 there was little more than surmise about the temperature of goods delivered at the retail stores or the temperatures and times experienced by packages in the frozen food display cabinets. Morin *(9)* reported some temperatures measured in the cabinets. The research staff of the Birds Eye Division, General Foods Corporation, filled many of the gaps in knowledge by making extensive surveys, reported by Dykstra *(3)* and by Munter, Byrne, and Dykstra *(10)*. No doubt could exist after the appearance of these reports that a small proportion of frozen food packages experiences one or more actual defrostings and a larger proportion remains for considerable periods of time within the temperature range of 10° to 20° F., or even higher.

The U. S. Department of Agriculture was naturally concerned with the problem that so directly faced the frozen food industry. Not only had this industry grown to be a major outlet for many farm products, but also Department workers had done important pioneering research on the freezing of foods. Frozen food packers' and distributors' associations, transportation interests, and The Refrigeration Research Foundation urged the Department to undertake a comprehensive study of "the temperature requirements of frozen foods." The Department's Cold Storage Research Advisory Committee strongly recommended such research in its first report to the Department, dated January 1948, and has continued to support the work in each of its subsequent annual reports to the Department. Funds for initiation of the project were made available to the Western Utilization Research Branch (at that time known as the Western Regional Research Laboratory), where a major program of research on frozen foods was already under way. Substantial amounts of money have been expended by the Branch each year since 1948, at both its Albany and its Pasadena laboratories, to complete the physical facilities and carry on the experimental work.

Many able scientists and food technologists had, in fact, made careful studies of the stability of frozen foods, starting at least as far back as the work of Fulton *(4)* in 1904-5 on frozen pie-fruits. A survey of the literature discloses well over 100 pertinent references. Results of these earlier investigations on particular frozen commodities will be reviewed in the articles to follow in this series. A new systematic study was needed to close several important gaps in knowledge, broaden the coverage so as to take account of geographical and seasonal variations in products and of recently developed products and processing methods, and to obtain conclusive information about some questions on which the results of previous investigators have not been concordant.

OBJECTIVES OF THE INVESTIGATION

Our project has therefore had the following major objective:

(1) To determine how frozen food products behave under conditions of time and temperature such as they may actually experience in the commercial distribution system, and in this way to provide information comprehensive enough to enable industry to (a) settle upon and specify allowable or tolerable deviations from "ideal" distribution conditions and (b) concentrate efforts on improvement of the more critical operations or areas in the system; and the following two derivative objectives:

(2) Upon the basis of the above results, to discover or devise improvements in raw material selection and handling, processing, and packaging, such that the finished products will better withstand adverse subsequent experiences, and

(3) To seek tests of product quality that can be applied to a frozen food at any point in the distribution system to indicate how much it has changed and, if possible, to estimate where it stands in the scale of commercial acceptability.

The major objective above is particularly challenging because of the practical impossibility of duplicating all of the variations in temperature and time that may be experienced by frozen foods in the actual distribution system. The difficulty is discussed in the following section on "Analysis of the Experimental Problem."

The second objective of the current studies is to reinforce continuing advances in technology by focusing attention on specific types of product instability which still cause trouble. Improvement of the initial quality and the stability of frozen foods has been steady and impressive; just two out of many examples of progress are the use of ascorbic acid in the packing sirup to inhibit the browning of peach slices, and the use of waxy

cereal flours to increase the stability of frozen white sauces and gravies. Nevertheless, none of the problems of product instability can be regarded as completely solved. If the source of the difficulty can be identified the remedy may come immediately to mind; at any rate, a rational starting point for research is located.

Our third objective has been to discover tests which might be applied to products at any point in the distribution system, primarily to assist in the control and improvement of practice. Several investigators have correlated such objective changes as loss of ascorbic acid or conversion of chlorophyll to pheophytin with the gradual decline in acceptability of frozen foods during storage. The full significance of these tests needs to be determined. Others, appropriate for the many different kinds of frozen food, need to be devised. Objective tests are naturally preferred. Subjective appraisal remains, of course, as the basic element; the usefulness of objective tests generally depends upon demonstrated correlation with organoleptic evaluation. Improvement in the methodology of these organoleptic procedures is needed. Such tests may, indeed, be the only recourse in dealing with certain products.

ANALYSIS OF THE EXPERIMENTAL PROBLEM

Specific planning of experiments in which samples will be subjected to time-temperature schedules simulating those that may occur in actual commercial distribution involves selection of a reasonably small number of reproducible time-temperature patterns that, as a group, will substitute acceptably for the infinite variety of actual patterns. It is not sufficient to carry samples through a temperature history simulating "average" conditions; something like half the frozen foods in our markets experience worse treatment. The planning must include enough variations to cover the range between "probably satisfactory conditions" and "almost certainly unsatisfactory conditions," with a large enough number of single variations in pattern to enable the investigator to separate the effects.

If we knew that the various deteriorative changes are merely additive it would be sufficient simply to study the effects of several steady temperatures, apply the rate of deterioration at each temperature to the various phases in the history of a frozen product, and add the separate parts to get the total amount of change. However, we do not know that to be true. Experiment is required to determine the extent of validity of the hypothesis. If it is shown to be widely valid, future investigations of the stability of new or improved frozen foods will be greatly simplified.

A special case which has already attracted the attention of a number of investigators is the "fluctuating temperature." Does repeated fluctuation of product temperature produce a specific effect different from that of any intermediate temperature within the fluctuation range? Reported experiments do not give a completely concordant answer, except that evidence for an irreversible moisture transfer in some kinds of product ("cavity ice" formation) seems conclusive. Hicks *(6)* and Schwimmer, Ingraham, and Hughes *(12)* have published mathematical analyses of systems in which a chemical reaction takes place during a periodic fluctuation of temperature. If the temperature coefficient of the reaction is known, an equivalent steady temperature can be computed. This will always be intermediate between the highest and lowest temperatures in the cycle and for a positive coefficient will always lie above the arithmetic mean temperature. The analysis necessarily assumes that there is no specific effect of the fluctuation itself, and is not applicable if two or more reactions, having different temperature coefficients, proceed in the system concurrently or consecutively. If two such reactions do occur the net effect of exposure at one temperature will always be qualitatively different from the effect of exposure at another temperature, regardless of length of time. Investigation of the existence or practical importance of a situation like this is needed, not only for systems experiencing a periodic fluctuation in temperature but also for those in which temperature undergoes even one change in level during the course of the experiment.

The development or improvement of various product tests, mentioned above as our third objective, is important only insofar as good correlations can be established between these tests and either (a) the quality or acceptability of the product or (b) the temperature history of the product since it was packed. Both types of correlation would be useful, although for somewhat different purposes. The first, resting as it does upon those most elusive concepts, "quality" and "acceptability," can be established only through the joint efforts of the laboratory scientists and experienced merchandisers of frozen foods because it involves making at least a semi-quantitative esttimate of consumer reactions. If successful, it would enable an investigator to examine the contents of a package and conclude, for example, that "While this sample is now acceptable, it will have to be handled quickly and with extra care from here on or the consumer will not find it so." From the nature of the case, this kind of test and correlation would reflect the entire history of the product—raw material selection and handling, processing procedure, and packaging, as well as all its subsequent experiences.

A correlation of product tests with past temperature history would be aimed to make possible such statements as, "This sample has been through an experience equivalent to x weeks at 20°," or, "This sample has experienced at least one complete defrosting." Extensive experimentation is necessary before the possibilities and limitations of such tests can be known. We need, if possible, to separate the product characteristics which can only have been acquired subsequent to packing from all of the normal characteristics—and their variations—of a freshly packed product. The chance of being able to do so will differ from one commodity to another. Again, the practical possibility of expressing any temperature experience in terms of equivalence to a time at some common-denominator temperature such as 20° F., or to an expression related to the horticulturist's "degree-days," must be determined by experiment. As discussed in an earlier paragraph, if two or more deterioration reactions are involved, exposure to a higher temperature may not only increase the rate of change but also alter the qualitative character of the change. For example, if a reaction which produces texture

change in a commodity has a greater temperature coefficient than a reaction that causes darkening, loss of texture could be the life-limiting factor at a relatively high temperature level, but discoloration be the limiting factor at a lower temperature. No length of time at some intermediate temperature would be exactly equivalent in effect to either. One might note that the temperature coefficients of some reactions (for example, any reaction dependent on the diffusion of dissolved oxygen) may be very high indeed in the range of temperatures where most of the liquid-solid phase transformation occurs.

"Defrosting indicators," such as have been proposed by Anderson *(1)* and others constitute a special kind of limited indicator of temperature experiences. Emphasis has generally been placed on indication of complete defrosting, because of rapid spoilage of some foods under these conditions. Our project has not been directly concerned with development of such external indicators, but our experimental results will provide a statement of the basic requirements—in particular, what combinations of time and temperature are equivalent to one another in their effect on various products.

THE EXPERIMENTAL ATTACK

In view of the importance of the problem, planning for the work laid stress on assuring the conclusiveness of results. We sought to guard against findings based on atypical materials by repeating procurements in 2 or 3 packing seasons and by procuring from each of the major producing sections for most of the commodities. For example, frozen strawberries, either in the consumer size or the institutional size pack, were produced from plants in California, Oregon, Washington, Tennessee, and Louisiana, snap beans from Oregon, Tennessee, California, and New Jersey. Forty different "lots" of frozen peaches have been procured, totaling some 6000 separate packages, and altogether more than 50,000 packages of the various commodities have been obtained and put under test.[a] For the frozen fruits and vegetables these conditions virtually dictated the use of commercially packed materials. In addition, however, small experimental packs have been included in the test in some cases in order to furnish additional information about the effects of processing variables. Poultry products and precooked foods were in part prepared in the laboratory, in part purchased from commercial producers. Use of commercially packed goods of course offered the additional advantage that when a sufficiently broad selection was made the results of the work would undeniably be directly applicable to industrial operations. Purchased lots of the various commodities were usually packed in the presence of a member of our staff; full information on the raw material and processing conditions was obtained. Some lots were of commercial grade A product, others were grade B. The major commercial freezing methods were represented by lots procured from the different plants. Shipments to the laboratory were made at below zero temperature.

[a] A substantial proportion of the frozen foods tested has been purchased with funds made available by the Refrigeration Research Foundation under a Memorandum of Understanding with the Department.

Commodities included in the study so far are strawberries, peaches, red sour cherries, raspberries, California orange juice concentrate, peas, snap beans, spinach, cauliflower, whole ready-to-cook turkeys, cut-up chicken fryers, cut-up stewing hens, several precooked poultry products, and sauces and gravies used in precooked items. Other fruit and vegetable products, additional precooked foods, and certain cooked and uncooked bakery goods will be included in future studies. No plans have been made to study such other classes of frozen food as meats (other than poultry), fish and other seafood, and dairy products.

Design of the experiments has embraced exposure of samples to a variety of temperature patterns simulating several degrees of adversity in distribution conditions; to several temperature patterns designed to test the additivity of effects; to temperatures fluctuating regularly over several different ranges for a long period of time; and to temperatures maintained steadily at —30°, —20°, —10°, 0°, 5°, 10°, 15°, 20°, 25°, 30°, and 40° F.—those at the lower temperatures for extended periods of time. One of the patterns simulating a possible transportation experience is shown in Figure 1. The first 11 days of this pattern were taken from an actual record of transcontinental shipment of frozen food—not necessarily a typical or average experience. A pattern simulating a possible experience in the break-up room and the retail cabinet is shown in Figure 2; this is an assumed temperature pattern, not based upon an actual record.

In one series of experiments the following combinations of exposures were carried out:

(a) The pattern of Figure 1, then 8 months at 0° F., then the pattern of Figure 2.

(b) Eight months at 0° F., followed in succession by the patterns of Figures 1 and 2.

(c) The pattern of Figure 1, then immediately the pattern of Figure 2.

(d) The pattern of Figure 2 only.

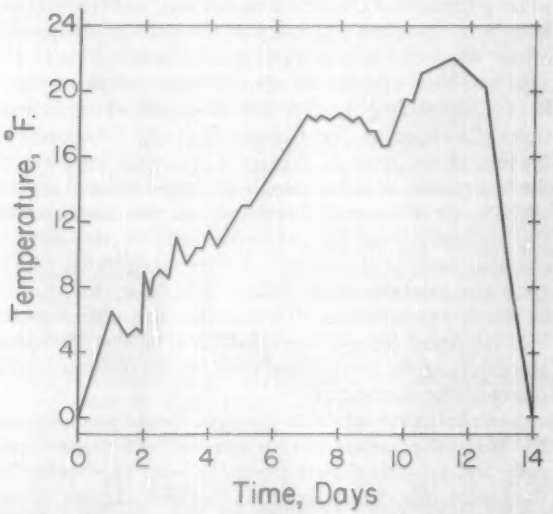


Figure 1. Product temperature measured during an actual shipment—used as one of the simulated transportation temperature patterns.

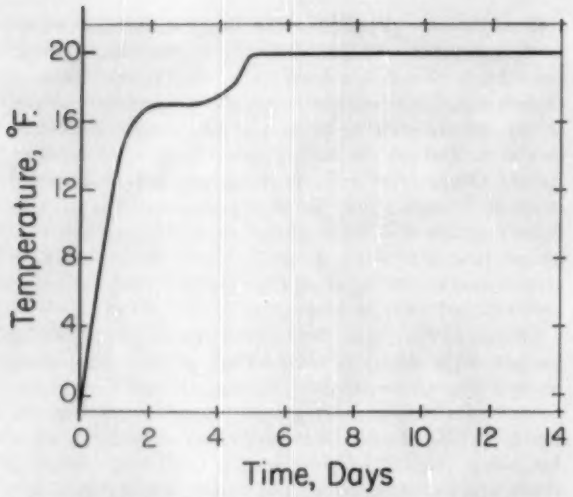


Figure 2. Temperature pattern simulating a possible experience in the break-up room and the retail cabinet.

Other patterns representing both worse and better conditions have been used.

The temperatures of primary interest are, of course, those experienced by the frozen product itself, rather than ambient air temperatures. Any one test required exposure of as many as 700 packages to as nearly as possible identical but time-varying conditions, and repeating the identical exposure with new lots of material in one or two subsequent years. Experiments on the effect of temperature fluctuation involved sine-wave variations of temperature on a 24-hour cycle, with amplitudes of as much as 20° F. These requirements dictated that in experiments including variations of temperature with time individual packages (rather than cased goods) should be exposed in the test chambers to air circulating at a carefully controlled velocity. Automatic program-control of the temperatures was essential. In order to carry out a variety of different exposures simultaneously on the same lot of frozen material a battery of these test rooms was required. Nine have been installed and used in the Albany laboratory of the Western Utilization Research Branch. Their design involved solution of several unprecedented problems. Engineering features will be described in publications elsewhere by the Engineering and Development Section of the Branch. Figure 3 is a view into one of the test rooms, showing sample packages arrayed on the shelves; air of controlled temperature circulates around the packages from the perforated wall of the plenum chamber back of the shelves. Other refrigerated rooms were also available in the Albany laboratory for storage at steady temperatures. Two smaller test chambers, of less elaborate design, were installed in the Pasadena laboratory of the Branch and used for the tests on frozen orange juice concentrate.

Samples removed from the test rooms according to the planned schedule were examined both organoleptically and by such objective tests as were appropriate to the commodity. Objective tests included various chemical determinations and physical measurements, and also determination of changes in the number and character of the microbiological flora in the product. The panels of judges for the organoleptic tests were composed of members of the laboratory staff who are trained in these procedures and are acceptably consistent in acuity of perception. In addition, experienced persons from various segments of the frozen food industry have on several occasions examined groups of samples that had been subjected to a graduated series of damaging exposures, and have recorded their estimates of probable consumer reaction. It may be anticipated, of course, that the first detectable change will generally be picked up under controlled laboratory conditions earlier than under conditions of ordinary consumption. Evaluation of the significance and use of such tests as these, and translation of the results of the "time-temperature tolerance" investigation into terms of improved practices,

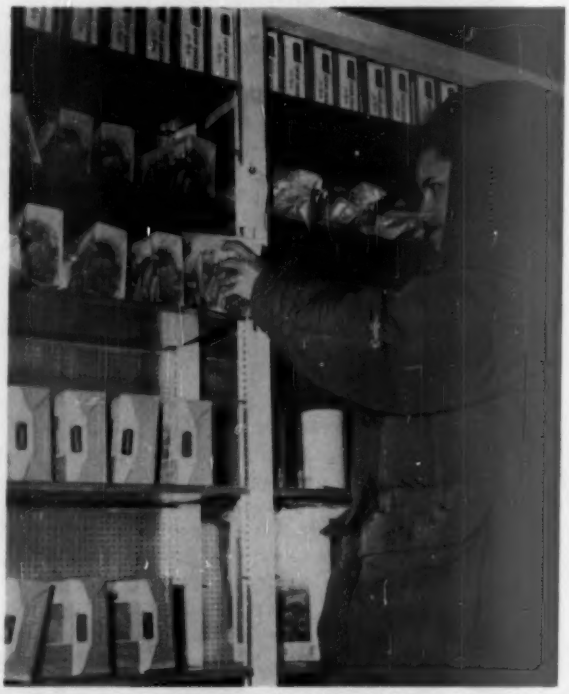


Figure 3. Several poultry products under test in one of the refrigerated rooms specially constructed and used for this work.

standards, or regulations, will be matters for consideration and decision by all the interests concerned.

One generalization apparent both from work on this project and from published reports by others is that the quality and acceptability of frozen foods are eroded away by every experience, whether it be holding for a long time at even a "good" temperature or experience of a higher temperature for even a short time, and the erosion is progressive and irreparable. Workers on the project have a saying, "Frozen foods have a memory for adverse experiences." The reader of articles in this series is therefore urged to interpret the results in terms of the integrated sequence of all the many steps between production of the commodity and delivery of the product to the consumer. Every one of these steps subtracts something—much or little as may be—from the quality.

Publication Plans

Detailed results of the investigation will be presented in FOOD TECHNOLOGY as soon as available for publication during the next several years. The first such detailed report appears elsewhere in this issue. Versions of the results written from the standpoint of the particular interests of various segments of the frozen food industry will also be offered to appropriate trade publications, both in this country and abroad. It is expected that eventually a full review of the entire investigation will be brought together, possibly as one or more U. S. Department of Agriculture bulletins.

Acknowledgment

The writer of this article is simply spokesman for a large group of his colleagues in the Western Utilization Research Branch. He has not been directly active in the project at any time. Ideas expressed here are the outgrowth of numerous stimulating discussions with many of the research leaders and workers directly concerned, and whose names will appear as authors of the articles to follow. Special acknowledgment must be made of the vital role played in the initiation and earlier stages of the project by three men no longer connected with the Branch—J. R. Matchett, Assistant Director of Utilization Research, Washington, D. C., R. R. Legault, Washington State College, Pullman, Wash., and H. S. Olcott, University of California, Berkeley, Calif. Both during the planning and in the course of the work important information and counsel have been given freely by numerous technical men from various segments of the frozen food industry. The personnel of many freezing plants cooperated by furnishing production information about the lots of frozen food procured for the work. Information from the General Foods survey of temperatures and times encountered in the distribution system was made available to us in advance of publication by H. J. Humphrey and K. G. Dykstra. Temperature records of many rail shipments of frozen foods were furnished by W. T. Pentzer, U. S. Department of Agriculture, C. A. Richardson, Association of American Railroads, and Kenneth Plummer, Pacific Fruit Express Co. The counsel received from H. C. Diehl, Director of The Refrigeration Research Foundation, has been especially helpful.

LITERATURE CITED

1. ANDERSON, A. A. A defrosting indicator for frozen foods. *Food Technol.*, 3, 357-358 (1949).
2. ANDERSON, O. E. *Refrigeration in America.* 1953, Princeton University Press, Princeton, N. J.
3. DYKSTRA, K. G. Distribution practices in the frozen food industry. *Canner*, 114, 16, 18-19 (Mar. 15, 1952).
4. FULTON, S. H. *Cold Storage of Small Fruits.* U.S.D.A., Bur. Plant Ind. *Bull. No. 108* (1907).
5. HARVEY, E. M., AND REDIT, W. H. Transportation of frozen citrus concentrates and other frozen foods. *Food Technol.*, 9, 74-77 (1955).
6. HICKS, E. W. Note on the estimation of the effect of diurnal temperature fluctuations on reaction rates in stored foodstuffs and other materials. *J. Council Sci. Ind. Research* (Australia), 17, 111-114 (1944).
7. HUMPHREY, H. J. Temperatures for frozen foods. *Ice and Refrig.*, 121, 52, 54, 56, 58 (Aug. 1951).
8. LARSON, J. S., MIXON, J. A., AND STOKES, E. C. *Marketing Frozen Foods.* U.S.D.A., Prod. and Market. Admin., June 1949. Washington, D. C.
9. MORIN, E. L. What happens to frozen foods: Retail practices. *Quick Frozen Foods*, 14, 65-67 (Apr. 1952).
10. MUNTER, A. M., BYRNE, C. H., AND DYKSTRA, K. G. A survey of times and temperatures in the transportation, storage, and distribution of frozen foods. *Food Technol.*, 7, 356-459 (1953).
11. PENTZER, W. T. Performance tests on refrigerator cars. *Food Technol.*, 3, 410-415 (1949).
12. SCHWIMMER, S., INGRAHAM, L. L., AND HUGHES, H. M. Temperature tolerance in frozen food processing. *Ind. Engin. Chem.*, 47, 1149-1151 (1955).

The Time-Temperature Tolerance of Frozen Foods. II. Retail Packages Of Frozen Peaches

D. G. Guadagni, C. C. Nimmo, and Eugene F. Jansen
Western Utilization Research Branch, Agricultural Research Service, United States Department of Agriculture, Albany 10, California

(Manuscript received August 18, 1956)

WHEN PREMIUM QUALITY PEACHES are properly harvested, handled, processed, and frozen, they are probably one of the best frozen fruits commercially available today. During the past 25 years a great deal of study has been devoted to variety selection, harvest maturity, processing techniques, and freezing methods *(15)*. This effort has led to notable advances, especially in the field of processing. The introduction of sirup as a packing medium and the discovery that ascorbic acid retards the development of surface discoloration were among the foremost developments in frozen peach processing technology *(2, 3, 9, 10, 15)*. It was also recognized that proper storage temperatures are necessary to retain the top initial quality made possible by proper harvesting, handling, processing, and freezing *(4, 16)*. Over a period of years, 0° F. was selected as a practical and satisfactory storage temperature with respect to economy and quality retention. It has been shown, however, that product temperatures of 0° F. are not always maintained during the distribution of frozen foods *(13, 14)*. The general problem of quality loss during transportation and distribution is discussed by Van Arsdel in the first article of this series *(18)*. The present report is concerned with the effect of various time-temperature experiences (including steady and fluctuating temperatures and simulated distribution patterns) on quality of commercially packed frozen peaches.

MATERIALS AND METHODS

All the frozen peaches used in these experiments were purchased from commercial processing plants located in California, Washington, and Georgia. Samples were obtained during 5 seasons and represented the major commercial freezing varieties which are used in these areas. Generally, the peaches were sorted for maturity, peeled with lye or steam, cooled and washed, pitted, sliced and packed in 50-55° Brix sirup containing ascorbic acid. Most of the samples were packed in composite metal-end cartons (10-, 12-, and 16-oz. sizes) and a limited number in hermetically sealed 10½-oz. tin cans. Most of them were frozen in air-blast freezers operated at 0° to —20° F. and some were frozen in plate freezers operated at —20° F. After freezing, the samples were shipped to Albany, Calif., in insulated containers refrigerated with dry ice to maintain temperatures below 0° F.

During this 5-year period 52 different "lots" of peaches ranging from 120 to 900 packages each were obtained. Each lot was selected so as to include as many different commercial variables as possible; these included variety, maturity and ripen-

ing practices, locality, packaging material, etc. The fruit in each individual "lot", however, was as uniform as possible under commercial operating conditions.

Storage of several samples at temperatures between 0 and 30° F. repeatedly indicated the development of similar deteriorative changes; the major differences due to temperature were with respect to rate of deterioration, and therefore 20° F. was selected as a convenient temperature for comparison of the storage behavior of different "lots" of fruit under accelerated conditions. In order to determine effect of temperature on rate of deterioration, several "lots" were stored at 0°, 10°, 15°, 20°, and 25° F. for varying times. To determine the effect of various time-temperature sequences on quality deterioration, samples were exposed to 10, 15, and 20° F. for one and two weeks, then cooled to 0° F. and held there for intervals of 3 months and one year. Following these storage periods at 0° F. the samples were again stored at 10° and 20° F. Other samples from the same lot were stored at 10° and 20° F. after 3 months and one year of storage at 0° F., but without prior storage at 10°, 15°, and 20° F. The purpose of this experiment was to determine whether the deteriorative changes were essentially additive or cumulative, or whether initial exposure to higher temperatures in some way caused a more rapid rate of deterioration during subsequent exposure to unfavorable temperatures.

The effect of actual transportation and distribution practice was estimated by constructing various time-temperature patterns which the product might experience during transportation cross country and subsequent distribution. These temperature cycles were patterned after determinations of product temperatures encountered during transportation, distribution, and retail cabinet storage *(1, 14)*. These patterns were automatically duplicated in refrigerated rooms specifically designed for this purpose *(12)*. A typical example of one of these patterns is shown in Figure 1. A part of the packages from each lot was held at a

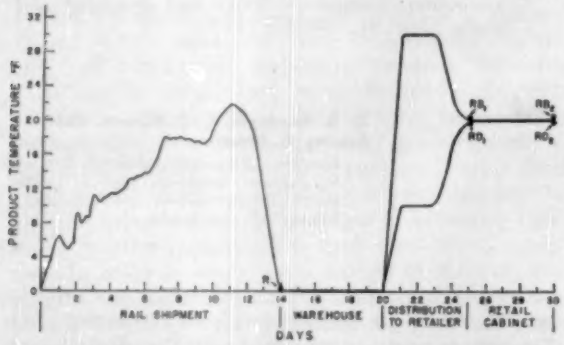


Figure 1. Variation in product temperature during simulated transportation and distribution.

steady temperature of —20° F. These served as controls for the samples stored at higher temperatures. After each storage period at the experimental temperatures 4 to 6 packages from each lot were removed and immediately cooled to —20° F. All experimental and control samples were held at this temperature until they were evaluated.

Organoleptic evaluation. Three methods of organoleptic evaluation were used. Regardless of the specific method used, all samples were thawed in front of an electric fan at room temperature (approximately 70° F.) for 2 hours.

The thawed fruit was placed in white enamel pans and scored for each of the following factors on a rating scale of 8 to 1: color, flavor, and overall quality. Three experimental samples and one hidden control were compared against a labeled control assigned a score of 8.0 for all quality factors. Each sample was replicated 3 to 4 times by 10 to 15 trained judges, and the scores were averaged and statistically analyzed.

Most of the samples were evaluated by the triangle method, since it was found early in the experiments that it is especially sensitive in the discovery of small flavor and color differences. The samples were thawed, placed in white enamel pans, and evaluated for color under standard daylight lamps. Immediately after judging color, any severely browned slices were discarded and each remaining slice was cut into 3 or 4 pieces. This reduction in piece size facilitated mixing of the sample and resulted in more uniform servings for flavor evaluation. Flavor was evaluated under subdued lighting so as to eliminate color differences between stored and control samples. Ten to 15 trained judges were used for the color and flavor evaluations and significance of the results was obtained from *Tables of the Binomial Probability Distribution (17)*. The organoleptic tests were made after successive storage periods at various temperatures, resulting in 6 to 10 tests for each temperature or temperature cycle with 2 to 3 replications for each test. Results with the triangle test at a probability level of 0.05 to 0.01 are considered as barely noticeable differences for either color or flavor and are generally referred to as first detectable differences, corresponding to 11 to 12 correct judgments out of 20, or 15 to 17 out of 30.

Because it was felt that first detectable differences by the triangle test were generally smaller than those which would be readily apparent to the consumer, an approximation of consumer reaction was considered desirable.

An estimate was obtained by submitting samples representing varying degrees of time-temperature damage to groups of quality-control experts and industry executives. The quality-control experts were well acquainted with the type and nature of quality defects that result in consumer complaint. These people graded the samples as good, acceptable, poor, or sufficiently poor to cause consumer complaint. These groups ranged from 19 to 54 persons and were able to make 4 evaluations on material obtained during different seasons.

Chemical and physical methods. Four packages from each time-temperature experience were thawed and then drained for 2 minutes on 8-mesh stainless-steel screens. From the package net weight and drained weight the percentages of fruit and drained sirup were calculated.

After draining, all noticeably discolored slices were counted and expressed as number of brown slices per package. Intensity of browning was determined by placing slices in matched glass dishes and taking reflectance measurements on the Hunter Color and Color Difference Meter. The instrument was standardized with a visually matched standard tile obtained from National Bureau of Standards. The values used for this tile (SBC-35) were as follows: $Rd = 54.0$, $a = 1.0$, $b = 32.0$.

Ascorbic acid was determined by the method of Loeffler and Ponting *(11)* on composite samples of drained fruit and drained sirup. Soluble solids were determined by refractometer and expressed as percent sucrose.

RESULTS

Effect of browning on overall quality. During the 5-year period over 10,000 packages of frozen peaches have been stored under a variety of time-temperature conditions and examined for changes in quality. Without exception, the first, most important, and most noticeable quality change in samples stored above 0° F. has always been browning or oxidation of slices exposed to the headspace atmosphere. It is well known that when a package of frozen peaches is viewed in a bowl or pan, the presence of discolored or brown slices tends to influence the judge adversely with regard to overall quality. As shown in Figure 2, there is an essentially

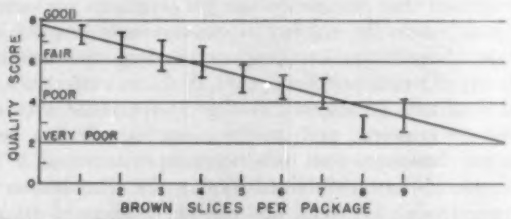


Figure 2. Effect of number of brown slices on average overall quality score.

linear relationship between quality score assigned by a trained panel and number of brown slices per package. As brown slices increase, average quality score decreases, indicating that overall quality of a given package of peaches is largely judged on the basis of oxidative discoloration. Undoubtedly the acceptability of frozen peaches to most consumers is also largely influenced by the presence or absence of undesirable discoloration. In this connection it is interesting to note that the four groups of quality control experts and industry representatives who graded a series of samples representing varying degrees of damage were almost unanimous in their opinion that discoloration is of utmost importance in determining acceptability of frozen peaches. Based on the color of experimental samples, these groups were also practically unanimous in their opinion that storage of average commercial samples of frozen peaches at 20° F. for one to two weeks causes enough discoloration to rate the product low in quality or sufficiently poor to cause consumer complaint. These expert opinions on consumer reaction are in good agreement with subjective color results obtained by our trained panels. Approximately 90% of the 52 lots examined for color changes were found to be significantly altered after one to two weeks at 20° F. Therefore the first color changes detected by trained panels using the triangle test are considered objectionable and commercially undesirable. In view of the paramount importance of color, most of this paper will be devoted to factors affecting changes in color during storage at temperatures above 0° F.

Up to this point evidence has been presented that browning influences the assessment of overall quality of the pack, without reference to flavor. Actually Table 1

TABLE 1
Relative rates of color and flavor change in retail packs of frozen sliced peaches

Temperature, °F.	Days required to become significantly different from —20° F. control	
	Color	Flavor [1]
15	17	42
20	6	17
25	2	10

[1] Refers to flavor of relatively unbrowned fruit.

shows that significant color changes appear in approximately one-third the time that detectable flavor changes occur in unbrowned slices during storage at 15 to 25° F. The flavor of severely browned slices is altered as a result of browning, and the flavor change varies directly with degree or intensity of browning. These results are typical of the many samples examined at these temperatures and indicate that storage life of frozen peaches at the temperatures considered could be approximately tripled if oxidative color changes could be controlled or eliminated.

Effect of container fill. It has been reported *(7)* that in carefully prepared laboratory packs stored at 20 to 28° F., the number of brown slices per package was determined by degree of container fill. Browning in composite containers was materially reduced when package headspace was practically eliminated by increasing amounts of sirup.

The weight distribution of one large lot of 957 commercial samples (12-ounce size) is shown in Figure 3. From this distribution chart, it is clear that variation in package net weight is considerable. Furthermore, it is unfortunate that packages containing the correct net weight for their particular size have enough free headspace to allow a serious amount of browning when stored at elevated temperatures.

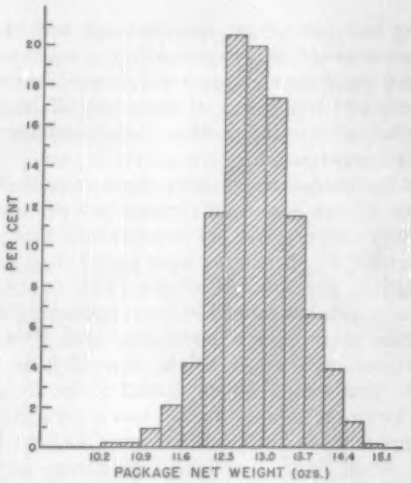


Figure 3. Distribution of package net weight in a single "lot" of commercially frozen peaches.

Figure 4 shows a fair linear relationship between net weight and number of brown slices in 16-ounce composite containers stored at 20° F. for 2 weeks. Packages with a net weight of 16 ounces averaged 5 to 6 brown slices per package under these experimental conditions. Since most packages contained approximately 20 slices, the number of brown or discolored pieces ranged from 25 to 30% of the total. This amount of discoloration seriously damages the appearance and

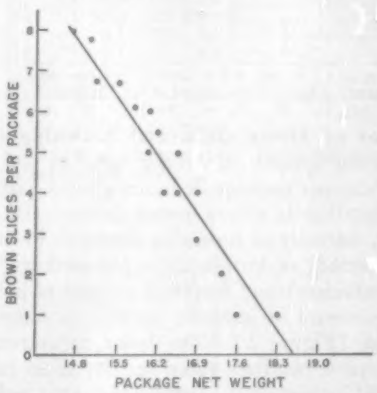


Figure 4. Effect of net weight on number of brown slices per package.

acceptability of the product. The only samples that remained relatively free from discoloration (1 brown slice or less) under this time-temperature condition were more than 2 full ounces overweight. The points on the graph represent lots obtained from various plants; this fact may explain in part the rather wide variation in net weights. However, most of the packages weighed 16 ± .75 ounces. The fact that the relationship between

browning and net weight was obtained with different lots representing different varieties, localities, and processing conditions rather conclusively demonstrates the paramount importance of container fill in limiting the number of discolored slices during storage at unfavorable temperatures.

Table 2 demonstrates further the profound effect of container fill on quality of frozen peaches stored at unfavorable temperatures. It is interesting that prior to storage at 20° F., all samples were scored from 7.4 to 8.0 regardless of package net weight (14.8 to 19.0 oz.). Apparently, peaches packed in sirup containing ascorbic acid retain their quality reasonably well if stored at temperatures of 0° F. or below, even if there is considerable headspace. When stored 7 to 25 days at 20° F., however, a rapid quality loss occurs in samples whose net weights are in the range of 14.8 to 16.2 oz. On the other hand, practically no change in quality occurred in the net weight range of 19.0 oz. and above, even after 76 days at the same temperature. Since it has already been shown that overall quality is inversely related to number of brown slices per package, it is evident that no important amount of browning occurs during storage at 20° F. for 77 days in samples containing 19.0 oz. or over. Furthermore, it is also apparent that quality deterioration, other than browning, did not occur to any great extent; otherwise, it would have been reflected in a much lower quality score.

TABLE 2

Effect of package net weight on the quality of frozen peaches stored at 20° F.

Average net weight (oz.)	Average quality scores [1]						
	Days of storage						
	0	7	25	34	45	56	76
14.8-15.5	7.8	5.9[2]	4.6	4.4	4.5	5.3	....
15.5-16.2	7.5	6.2[2]	5.8	5.5	4.5	4.8	4.6
16.2-16.9	8.0	7.8	6.4[2]	5.1	....	....	5.1
16.9-17.6	7.7	7.4	6.7[2]	7.3	6.6	5.6	5.6
17.6-18.3	7.8	7.8	7.7	7.4	....	7.4	6.8[2]
18.3-19.0	7.8	....	7.6	7.7	6.9	7.6	7.4

[1] 8.0 = *good*, 6.0 = *fair*, 4.0 = *poor*, 2.0 = *very poor*.
[2] Significantly different from control at the 5% level.

Number of brown slices and browning intensity. In assessing quality of frozen peaches by counting brown slices per package, it is recognized that intensity of discoloration is also a major factor. As might be expected, intensity of browning increases in direct relation to number of brown slices per package (in composite containers) and therefore a count of brown slices gives a measure of intensity as well as extent of discoloration (Figure 5). The color measurements are averages of 4 readings taken on the slices counted as brown and located on the surface of the thawed package. As the number of brown slices increases, both *Rd* and *b* values decrease in essentially linear fashion. The *Rd* value measures percentage of light reflected from the surface, and as the slices become darker, more light is absorbed and hence the percentage of reflected light or *Rd* value decreases. The *b* value essentially gives a measure of yellowness, and as a result of enzymatic oxidation of phenolic compounds, the yellow flesh color is masked or "covered up" to an extent depending upon the degree of oxidation. Therefore, as degree or intensity of oxidation increases, the apparent yellowness of the flesh decreases and consequently the *b* value also decreases. Since both the *Rd* and *b* values decrease in a parallel manner with increasing browning, it is reasonably certain that development of brown-black pigments is the principal reason for the decrease in both values.

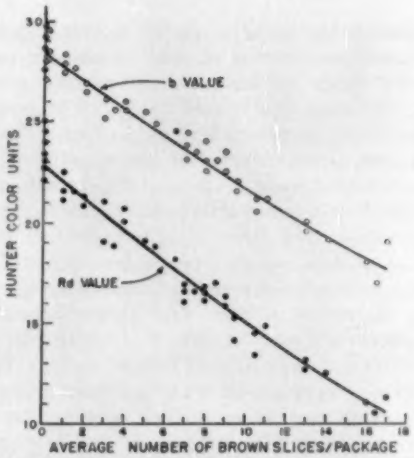


Figure 5. Relationship between Hunter color measurements and number of brown slices per package.

Ascorbic acid and browning. In the commercial preparation of frozen peaches it is customary to add ascorbic acid to sirup and meter a predetermined amount of sirup and acid into containers prior to filling with slices. The amount of ascorbic acid in the package is therefore determined by the amount of sirup, which also affects the degree of fill. Figure 6 shows the relationship between brown slices and ascorbic acid content of the sirup-juice mixture draining from the thawed peaches. As expected, the ascorbic acid content decreases as number of brown slices increases. However, it is important to note that this is the same general relationship observed between number of brown slices and package net weight (Figure 4). Since the ascorbic acid content of a given package is directly related to the amount of sirup added and since amount of sirup largely determines the degree of fruit coverage and package net weight, it is clear that degree of sirup coverage primarily determines extent of browning as well as ascorbic acid content of the package.

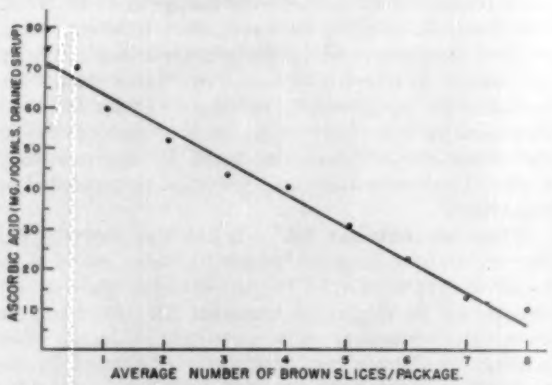


Figure 6. Relation between browning and ascorbic acid content of drained sirup.

A clearer picture of the effectiveness of ascorbic acid alone in preserving natural color of sliced peaches is shown in Figure 7. As the ascorbic acid in drained slices is reduced, an increasing degree of browning is indicated by the decline in both *Rd* and *b* values. There is an essentially linear relation between Hunter readings and ascorbic acid content of slices in the range of 0 to 10-11 mg./100 g. From about 10 to 17 mg./100 g., the Hunter readings tend to level off, indicating that relatively little browning took place in this range. However, it is important to note that slices must be

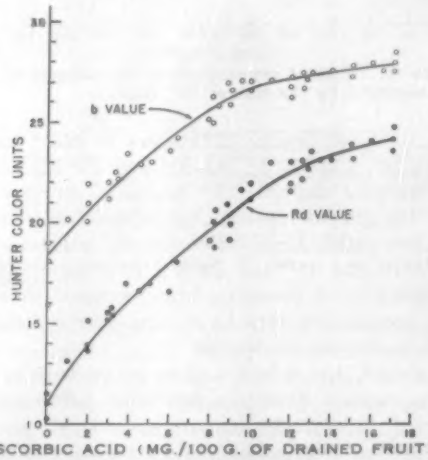


Figure 7. Relation between Hunter color measurements and ascorbic acid content of the drained slices.

submerged in sirup in order to absorb and retain sufficient ascorbic acid to prevent browning during storage at high temperatures. Even though completely immersed in sirup-ascorbic acid solution temporarily, slices which float in the solution and become exposed to oxygen in the headspace quickly lose the small amount of ascorbic acid adhering to their surfaces. On the other hand, submerged slices are protected from oxygen and retain ascorbic acid and natural color much longer. Figure 8 shows this relation for several lots obtained from two areas and stored at 20° F. Color of submerged slices, as measured by Hunter *Rd* value, did not change significantly during 65 days of storage. This was true of peaches obtained from both areas. In the exposed slices, however, a very rapid drop in *Rd* value occurred during the first 2 to 3 weeks. Thereafter, the *Rd* value decreased gradually, approaching a minimum corresponding to the maximum browning which is determined by the tannin and enzyme content of the peaches *(6)*. Generally, the exposed portions of the Northwest peaches were more intensely discolored than those obtained in California. However, the differences in rate and extent of discoloration attributed to these two areas are insignificant when compared to the differences that occur as a result of varying headspace or net weight.

Effect of steady temperatures on ascorbic acid content and browning. Since extent of browning in commercial samples has been shown to depend almost entirely on package net weight, the effect of temperature was determined on one large lot of 12-oz. containers in which all packages not falling in the range of 12 to 13.4 oz. were discarded. The samples within this range were randomized in such a manner that package weight distribution was practically the same for all storage temperatures. Therefore, the average net weight of samples for any given time-temperature experience was essentially the same even though the individual package net weights were different. Total ascorbic acid losses for

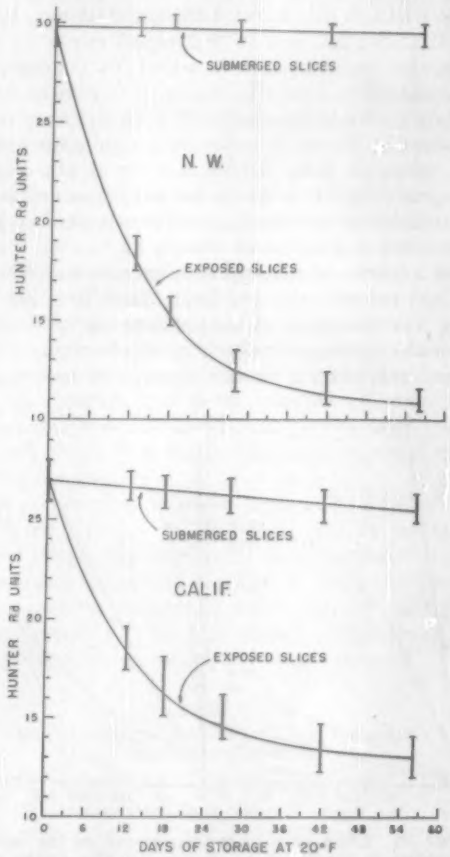


Figure 8. Effect of storage at 20° F. on the reflectance of exposed and submerged slices.

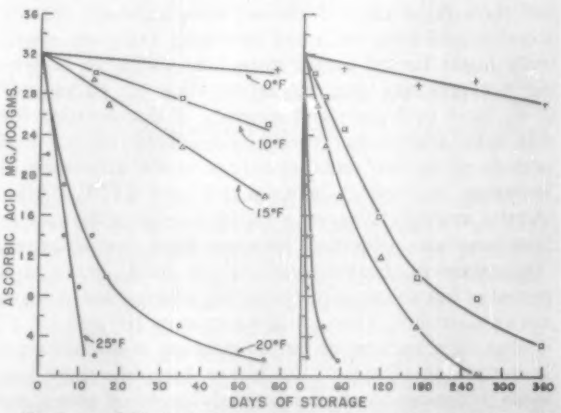


Figure 9. Effect of storage temperature on the ascorbic acid content of commercially packed frozen peaches (one uniform lot).

various times and temperatures are shown in Figure 9. A slight loss occurs after one year at 0° F., while practically all of the original ascorbic acid is lost after storage at 10° F. for the same period.

Since rate of loss for all temperatures is essentially linear until most of the ascorbic acid is oxidized, it may be useful to express the rate of loss for the linear portion of the curves as the amount lost per day. For this particular lot of peaches the rate of loss per day would then be 0.015, 0.135, 0.260, 1.55, and 3.03 mg./100 g. at 0°, 10°, 15°, 20°, and 25° F., respectively.

Although ascorbic acid is added to commercially frozen peaches to retard browning, it is evident that if the product were maintained at 0° F. this vitamin would be retained well enough to supply a significant portion of the minimum daily requirement. It is also evident that exposure to 20° to 25° F. for as little as one to two weeks makes the average pack of frozen peaches practically useless as a source of vitamin C.

Since a linear relationship between number of brown slices and ascorbic acid has been found, it is not surprising that the effect of temperature on browning is very similar to that for ascorbic acid reteniton. Figure 10 shows the relation between number of brown slices

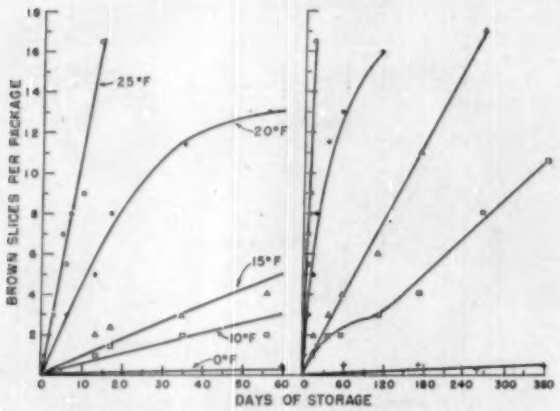


Figure 10. Effect of storage temperature on the incidence of browning in a uniform lot of commercially packed frozen peaches.

and days of storage at various temperatures. As for ascorbic acid loss, the initial browning rates are essentially linear for all temperatures. Incidence of browning averages less than one brown slice per package at 0° F. for 1 to 2 years and intensity of discoloration for this time and temperature is considered slight. For periods up to two months, only a minor difference in browning was noted between 10° and 15° F. After about 3 months, however, a rather marked difference in browning was observed between these temperatures. Apparently in the range of 10° to 15° F. there is a period of one to two months during which color changes are very similar. This similarity between 10° and 15° F. is even more pronounced when intensity of discoloration is considered (Figure 11). Up to 4 months there was some difference in the number of discolored slices, but intensity of browning was practically the same at the two temperatures. Storage beyond 4 months was required to show definite differences in color intensity between 10° and 15° F. At 20° and 25° F., however, both incidence and intensity proceeded at very rapid rates. The graphs representing incidence and intensity both show rather large differences in rate between 0° and 10° F. and 15° and 20° F. It is significant that these fairly rapid browning rates occurred in samples whose net weights were 12 oz. and over and therefore cannot be ascribed to slack fill.

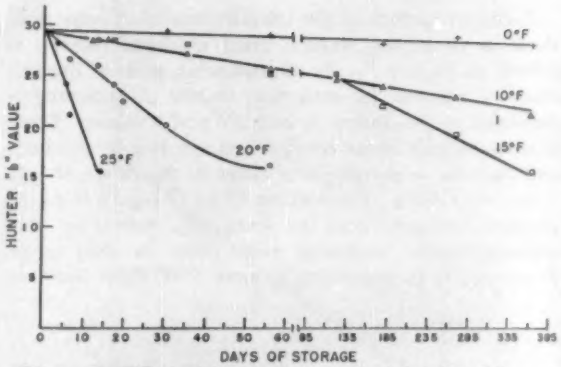


Figure 11. Effect of temperature on the intensity of browning as measured by the Hunter "b" value.

In general, 3 to 4 brown slices per package are sufficient to cause a definitely detectable difference when compared to controls and are considered to detract seriously from acceptability. Figure 12 shows the relationship between storage time at 20° F. and brown slices per package for several different lots obtained over a 5-year period. The large variation in brown slices for each of the storage periods is largely due to differences in degree of container fill, since none of these lots was segregated with respect to net weight. In spite of these

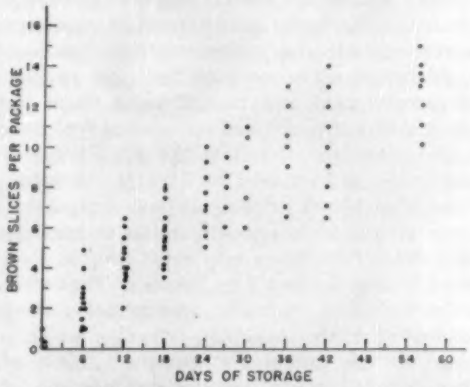


Figure 12. Effect of storage at 20° F. on the incidence of browning in various "lots" of commercially frozen peaches.

uncontrollable variations in net weight, there is a general trend of increased browning with storage. While several varieties were used, none appeared to be consistently better than others with respect to browning because of the variations in container fill, which nullified any real differences that might have been due to variety.

Cumulative effect of storage above 0°F. Flavor and color comparisons indicated no significant differences between samples stored at 10° to 20° F. initially

and those stored at these temperatures after 3 months or one year at 0° F. Even when storage at 10° and 20° F. was split by a 3-month or one-year period at 0° F., so that storage at the higher temperatures occurred both prior and subsequent to holding at 0° F., the total accumulated quality changes were not essentially different from those during equivalent uninterrupted storage. Figure 13 shows that color changes in frozen peaches exposed to 20° F. with intervening storage at 0° F. for up to one year are truly cumulative or additive. That is, 2 weeks at 20° F. causes approximately the same damage regardless of whether it is exposed immediately after packing or after one year at 0° F. or one week before and one week after a year's storage at 0° F. These findings also indicate that little or no damage occurs during one year at 0° F. even though the fruit was previously exposed to temperatures allowing quality changes to take place. Elaborate and extensive combinations of 10° and 15° F. storage with prior or subsequent exposure to 20° F. also failed to reveal anything except additive changes. Over a thousand packages were used in experiments on effect of various temperature sequences, and none of the data suggests that certain initial temperature sequences give rise to induction periods followed by markedly increased rates of deterioration during subsequent exposure to elevated temperatures.

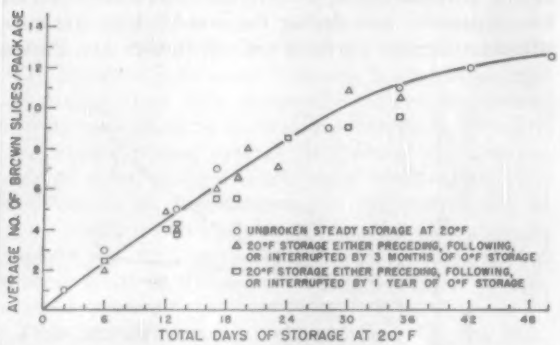

AVERAGE NO. OF BROWN SLICES/PACKAGE
TOTAL DAYS OF STORAGE AT 20° F
○ UNBROKEN STEADY STORAGE AT 20°F
△ 20°F STORAGE EITHER PRECEDING, FOLLOWING, OR INTERRUPTED BY 3 MONTHS OF 0°F STORAGE
□ 20°F STORAGE EITHER PRECEDING, FOLLOWING, OR INTERRUPTED BY 1 YEAR OF 0°F STORAGE

Figure 13. Cumulative effect of storage on browning of frozen peaches.

Effect of simulated practices in transportation, storage, and distribution. The original ascorbic acid content and percent retention during storage at 20° F. and simulated distribution practice are shown in Table 3. In spite of the approximately two-fold variation in original amount of ascorbic acid (17 to 35 mg./100 g.) found in the various lots, the percentage retention for any given storage condition generally did not vary more than 10 to 15%. The approximate percentage retention after 2, 4, 6, and 8 weeks' storage at 20° F. was 50 to 60, 30 to 40, 17 to 27, and 7 to 17, respectively. The retention data for the various distribution segments indicate 70 to 80% retention after the simulated transportation cycle which roughly corresponds to steady storage at 20° F. for 6 days. However, if this cycle is followed by exposure to 30° F. for 2 to 3 days, the retention drops to 30 to 45% and approximates storage at 20° F. for 4 weeks. On the other hand, if the product is maintained at 10° F. during the same distribution

TABLE 3

Comparison of storage at 20° F. and simulated distribution practice on ascorbic acid retention

Lot	Original A.A. content in mg./100 g.	Ascorbic acid retention, %										
		Storage at 20° F. in days						Distribution schedule[1]				
		6	14	18	28	42	56	R	RB_1	RB_2	RD_1	RD_2
A	17	72	56	50	40	22	10	80	42	20	76	62
B	18	67	57	47	40	20	9	80	43	26	70	60
C	19	73	50	42	30	18	11	67	30	26	68	52
D	25	78	54	50	36	27	12	74	45	23	67	60
E	26	80	50	41	33	20	9	80	32	24	76	50
F	28	75	58	49	29	22	7	75	30	22	73	70
G	30	70	50	53	42	27	17	78	36	20	63	58
H	31	76	58	45	39	23	11	75	36	31	70	60
I	33	70	51	49	36	17	13	80	30	25	70	62
J	35	75	52	50	34	19	8	74	45	35	70	61

[1] See Figure 1.

period following the transportation cycle, very little additional ascorbic acid is lost; and even after an additional 5 days at 20° F., the retention is in the range of 50 to 60%, which corresponds to 1 to 2 weeks' storage at 20° F. Although calculations for the interval from RB_1 to RB_2 suggest that the rate of ascorbic acid loss at 20° F. is somewhat greater after the samples have been thawed, the variations in commercial samples were too great to establish this point clearly. However, since the possibility of increased rate of loss after thawing definitely exists, it is highly important to guard against thawing temperatures.

The percentages of brown slices and subjective color and flavor changes in 10 typical lots of commercial samples during exposure to the same simulated distribution schedule are shown in Table 4. These data demonstrate again the paramount importance of package net weight or degree of fill with regard to changes in color during exposure to unfavorable temperatures.

TABLE 4

Quality changes occurring during a simulated distribution schedule

Lot	Average package net wt.	Percentage of brown slices per package				
		R	RB_1	RB_2	RD_1	RD_2
1	340	15[1]	53[1,2*]	63[1,2]	15[1]	24[1,2]
2	345	10	25[1,2]	26[1,2]	14[1]	30[1,2]
3	350	14[1]	28[1,2]	29[1,2]	15[1]	17[1]
4	354	4	27[1,2]	30[1,2]	3	19[1]
5	355	7	31[1,2]	32[1,2]	10	19[1]
6	355	10	26[1,2]	26[1,2]	10[1]	19[1]
7	358	6	24[1,2]	27[1,2]	8	13[1]
8	363	5	22[1,2]	24[1,2]	5	9
9	368	5	26[1,2]	30[1,2]	6	8
10	372	0	20[1,2]	24[1,2]	0	10

* [1] = Represents color difference from control at P = .01 using triangle test.
[2] = Represents flavor difference from control at P = .01 using triangle test.

Generally it would appear that most average commercial packs of frozen peaches can withstand a transportation cycle similar to the one shown in Figure 1 without significant color or flavor damage. However, it should be emphasized that even though a given time-temperature experience does not cause a significant quality change, the storage life of the product during subsequent exposure to elevated temperatures will be reduced by an amount depending on the severity of the original time-temperature experience.

It should be noted also that damage may readily occur

if container fill is not well controlled, and that slices in more completely filled containers are better protected against color damage. Lots 8, 9, and 10 (best container fills) apparently withstood distribution schedules R, RD_1, and RD_2 without significant color or flavor changes while the remaining lots all showed varying degrees of color change during these time-temperature sequences. The R, RB_1, and RB_2 sequences clearly show that exposure to 30° F. for even a few days following transportation causes very serious discoloration in even the better filled samples. In every lot exposed to this sequence both color and flavor were significantly changed. However, as shown earlier, where the time-temperature sequence was not so severe (R, RD_1, and RD_2), in most instances significant color changes appeared before flavor differences became noticeable. As for ascorbic acid retention, the color and flavor changes during this distribution schedule can be related to those at a steady temperature above 0° F. For example, the color damage as a consequence of R and RD_2 is similar but somewhat less than that during storage at 20° F. for 1 and 2 weeks, respectively. As mentioned earlier, there was no evidence that the changes with variable temperatures were significantly different from those at steady temperatures. The important factor in determining degree of damage is the total accumulated time-temperature experience regardless of the manner in which the experience takes place.

Effect of fluctuation. Commercial packs of frozen peaches were subjected to regular sine wave fluctuating air-temperature cycles from —5° to +5° to —5° F. and from 0° to +20° to 0° F. In both instances each complete cycle was repeated once every 24 hours. In the —5 to +5 cycle the product temperature lagged behind the air temperature by 2 to 3 degrees and the maximum and minimum temperatures attained were between +3° to 4° F. and —3° to 4° F. In the 0° to 20° F. cycle the product temperature varied between 2° and 18° F. and lagged behind the air temperature by 2 to 3 degrees. Evaluation of samples subjected to the —5 to +5 cycle indicated no significant color or flavor difference between those fluctuated and those maintained at a steady 0° F. This was true for periods of 2, 4, 6, and 12 months. The samples in which the product temperature fluctuated between 2° and 18° F. also failed to reveal any significant color or flavor differences when compared to similar samples held at a steady temperature of 10° F. for 2, 4, and 6 weeks. Thus it appears that fluctuation per se does not cause any significant acceleration of deteriorative changes in frozen peaches under these conditions. The changes brought about under regularly fluctuating conditions are indistinguishable from those at the mean steady temperature, probably because the precision of organoleptic methods is not high enough to determine small differences between samples which are changing at similar rates. These results are in agreement with other reports on the effect of fluctuating temperatures *(5, 8)*.

Effect of container. In 1952, two lots of peaches essentially equivalent in quality were obtained from a plant which packed in both tin cans and composite containers. Processing, handling, and freezing were similar for both lots except that because of slightly different fruit-to-sirup ratios, the samples in tin cans had a lower original ascorbic acid content. Figure 14 shows some striking differences with respect to ascorbic acid retention and browning when the two lots were stored at 25° F. Both ascorbic acid and color retention were far superior in the can, especially after 16 to 20 days at 25° F. It is interesting to note that after a slight initial loss of ascorbic acid during the first 10 days, this constituent remained constant without further loss during

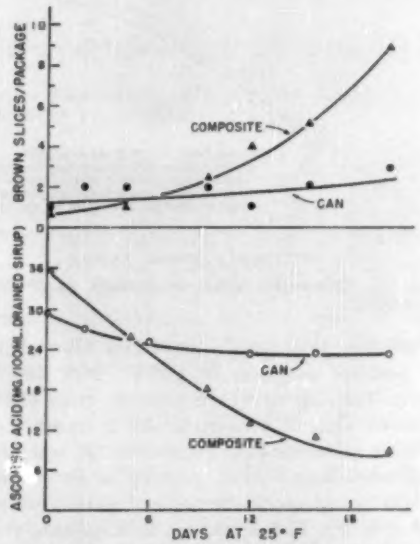


Figure 14. Effect of container on ascorbic acid retention and browning.

the remaining storage period. The amount of ascorbic acid oxidized in hermetic containers is of course limited by the amount of free oxygen in the headspace, whereas the porosity of composite containers allows oxygen to enter from the outside air and thus both ascorbic-acid oxidation and browning continue.

Drained weight and soluble solids. In all lots stored at 20° F. or below there was no significant difference in either drained weight or soluble solids of fruit or sirup between samples held at —20° F. and those stored at 0° to 20° F. for periods ranging from 4 months to 1 year. The drained weights of practically all lots fell in the range of 60 to 70% of the average net weight and no noticeable trends with respect to increase or decrease were observed during storage at 20° F. or below. Storage up to 3 weeks at 25° F. indicated no significant change in drained-weight percentage in any of the lots. In some lots, however, there was a definite trend toward increased soluble solids in the fruit and decreasing soluble solids in the drained sirup. During 3 weeks' storage the soluble solids of the fruit increased 2 to 3%, and the soluble solids in the juice decreased 2 to 4%. The greatest soluble-solids changes occurred in rapidly frozen samples, and essentially no change was observed in case or slowly frozen samples.

At 30° F. soluble-solids changes occurred rather rapidly regardless of freezing method. The soluble solids of fruit and sirup approached equilibrium in sam-

ples stored at this temperature for 6 to 10 days. The time required to reach equilibrium was largely dependent on size of slices and did not appear to be influenced by small variations in fruit-to-sirup ratio. Since solids equilibrium is not attained at temperatures below the thawing point of the fruit, the soluble-solids ratio between fruit and sirup obviously becomes an excellent thawing indicator. If a package of frozen peaches packed by usual commercial procedures is thawed, and the soluble solids of the drained fruit and sirup are essentially equal, it is practically certain that the package had been completely thawed for several days at some point in its previous temperature experience. Since frozen peaches in contact with oxygen undergo color changes much more readily than they equilibrate with respect to sugar, the distribution of soluble solids would be especially useful as a thawing indicator in vacuum-packed hermetic containers or in other fruits in which color changes are not so pronounced.

Time temperature equivalence. Since it has been shown that the controlling deteriorative reaction in the average commercial pack of frozen peaches is oxidative browning, time-temperature equivalence will be expressed in terms of this reaction. Figure 15 shows a

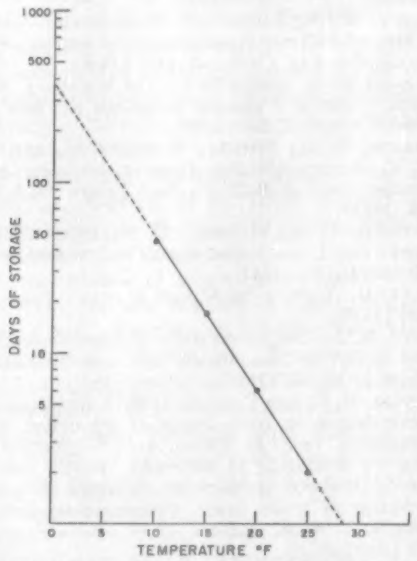


Figure 15. Time required for a significant subjective color difference at various temperatures.

linear relation between temperature in degrees Fahrenheit and the logarithm of days of storage required to bring about the first significant color change. Each point shown in the graph was derived from curves constructed by plotting the percentage of correct triangle color judgments against storage time at the various temperatures. Each curve was derived from the color data obtained from at least 6 storage periods at each temperature. The point at which the curve crossed the percentage of correct answers corresponding to a probability level of 0.01 to 0.05 was taken as the time required for a significant color difference to develop. The use of a sensitive test such as the triangle, with highly trained judges, and treatment of a relatively large volume of data in this manner, probably account for the linear relationship obtained. A linear relation allows estimation of the time at which a first significant difference would occur at any temperature within the range of temperatures studied. It has been indicated previously that color changes become noticeable approximately 3 times faster than flavor changes (unbrowned slices) in the temperature range of 15° to 25° F. However, at 0° to 10° F. it was found that first significant differences developed at approximately the same rate and therefore flavor as well as color becomes a limiting factor in this temperature range. As a matter of fact color changes at 0° F. are so slow that no significant browning occurs up to 2 years, whereas significant flavor changes are detected after one year. From this graph it is apparent that for each 5° F. decrease in temperature the time required for a significant difference to develop is approximately tripled and conversely the time is reduced by approximately one third for each 5° F. increase in temperature. It should be emphasized that the data for the graph were obtained from a large lot of material in which grossly overweight and underweight packages were discarded. As shown earlier, samples with little or no headspace would be stable for longer periods and those with more headspace would undoubtedly be less stable.

Figure 16 shows the effect of temperature on the relative rates of ascorbic acid oxidation, number of brown slices per package, and intensity of browning as measured by the Hunter *b* value. The significant point is the relatively slow rate of change for all 3 factors within the range of 0° to 15° F., compared to the rate changes from 15° to 25° F. The increase in rate from

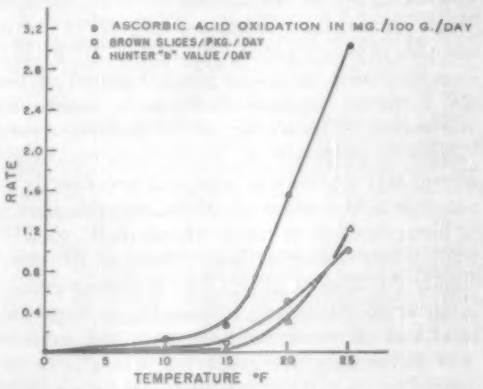


Figure 16. Effect of temperature on rate of ascorbic acid oxidation and browning.

0° to 15° F. is approximately one-fifth of the increase in rate from 15° to 20° F. for ascorbic acid oxidation and brown slices and approximately one-eighth of the rate increase for intensity of browning. Thus increasing temperature above 15° F. is very dangerous from the standpoint of color and ascorbic acid retention in frozen peaches. This is not meant to imply that storage at 10° or 15° F. is satisfactory. Even though the rates of deterioration are fairly low at these temperatures, signifi-

cant color differences can be observed after as little as one to two months of storage.

Table 5 shows the relation between temperature, time required for a significant color difference, ascorbic acid loss, incidence of browning, and browning intensity. In the 0° to 15° F. range the percentage of loss of ascorbic acid remains fairly constant for each time-temperature condition required to give a first significant color difference. At 20° and 25° F., however, the times required for equivalent subjective color differences result in 31

TABLE 5

Effect of temperature on ascorbic acid oxidation and browning as related to the first noticeable color difference

Temp. ° F.	Color difference[1]	Percent A. A. loss	Average no. of brown slices/pkg.	Δ Hunter "b" value
0[2]	—	13	.5	1.3
10	45	19	2.5	3.0
15	17	16	2.0	2.0
20	6	34	3.0	2.7
25	2	31	2.5	2.2

[1] Represents time required for a significant difference in days at a probability of .01 using the triangle test.
[2] After 1 year of storage.

to 34% loss of ascorbic acid, approximately double the amount in the 0° to 15° F. range. It will be noted that incidence and intensity of browning remain fairly constant over the 10° to 25° F. range. Thus the time required for an equivalent color change in this temperature range corresponds to a more or less constant factor for both number of brown slices and intensity of browning.

SUMMARY AND CONCLUSIONS

Results obtained on 52 different lots of commercially frozen peaches during 5 seasons conclusively demonstrate that degree of container fill is the most important single factor in determining degree of browning in samples exposed to temperatures of 10° to 25° F. The overall quality of frozen peaches stored in the 10° to 25° F. range has been shown to be directly related to the extent of browning, which is inversely related to degree of container fill or package net weight. Both extent and intensity of browning are directly related to ascorbic acid content. Initially, ascorbic acid is lost in a linear fashion at temperatures of 0° to 25° F. The rate of loss is several times greater at 10° than at 0° F. and at 20° than at 15° F. The browning-rate curves for these temperatures are very similar to those for ascorbic acid loss. Ascorbic acid retention and subjective color and flavor data are given for several lots of peaches stored under various time-temperature conditions. During storage at 25° F. samples packed in hermetically sealed tin cans retained ascorbic acid much better than similar samples packed in metal-end composite containers. Slight changes in soluble solids of both fruit and sirup were observed during storage at 25° F. but no significant differences were found in drained weight. At 30° F., however, the soluble-solids distribution between fruit and sirup rapidly approaches equilibrium. Fluctuating temperatures did not produce any quality changes other than those expected as a result of storage at the mean effective temperature. The rate of color change in frozen peaches packed in composite containers is influenced by time and temperature and availability of oxygen to the peach surface. The time required for a given change varies exponentially with temperature in the 10° to 25° F. range for packs of the type studied. The results must be interpreted in terms of the integrated sequence of all time-temperature experiences. Every experience subtracts something from the quality of the product and any given quality change represents the sum of all the previous individual time-temperature experiences.

Acknowledgments

The authors gratefully acknowledge the help and cooperation given by all the freezing plants where these commercial samples were obtained. The technical assistance of Margaret M. Stithem, Doris G. Sweny, and A. M. Mylne is also gratefully acknowledged.

LITERATURE CITED

1. Association of American Railroads, USDA Test No. 28. Final Report, p. 34 (Dec. 1948).
2. Bauernfeind, J. C., and Siemers, G. F. Adding ascorbic acid to peaches before freezing. *Food Inds.*, **17**, 745 (1945).
3. Bauernfeind, J. C., and Siemers, G. F. Retardation of discoloration in frozen sliced peaches by l-ascorbic acid. *Quick Frozen Foods*, **7** (12) 46 (1945).
4. DuBois, C. W., and Colvin, D. L. Loss of added vitamin C in the storage of frozen peaches. *Fruit Prod. J.*, **25**, 101 (1945).
5. Gortner, W. A., Fenton, F., Volz, E., and Gleim, E. Effect of fluctuating temperature on quality of frozen foods. *Ind. Eng. Chem.*, **40**, 1423 (1948).
6. Guadagni, D. G., Sorber, D. G., and Wilbur, J. S. Enzymatic oxidation of phenolic compounds in frozen peaches. *Food Technol.*, **3**, 359 (1949).
7. Guadagni, D. G., Stithem, Margaret M., and Nimmo, C. C. Factors affecting degree of browning in frozen peaches stored at 20-28° F. *Quick Frozen Foods*, **16** (11) 46 (1954).
8. Hustrulid, A., and Winter, J. D. The effect of fluctuating temperatures on frozen fruits and vegetables. *Agri. Engin.*, **24**, 416 (1943).
9. Joslyn, M. A. Why freeze fruit in sirup? *Food Inds.*, **2**, 350 (1930).
10. Joslyn, M. A. The present status of methods for improving the quality of frozen fruits and fruit products. *Fruit Prod. J.*, **13**, 142 (1934).
11. Loeffler, H. J., and Ponting, J. D. Ascorbic acid. Rapid determination in fresh, frozen or dehydrated fruits and vegetables. *Ind. Eng. Chem., Anal. Ed.*, **14**, 846 (1942).
12. Lowe, E., Barta, E. J., Rockwell, W. C., and Smith, G. S. Research facilities for the study of temperature tolerance of frozen foods. (Submitted for publication.)
13. Morin, E. L. Retail practices. *Quick Frozen Foods*, **14** (9) 65 (April 1952).
14. Munter, A. M., Byrne, C. H., and Dykstra, K. G. A survey of times and temperatures in the transportation, storage, and distribution of frozen foods. *Food Technol.*, **7**, 356 (1953).
15. Tressler, D. K., and Dubois, C. W. No browning of cut fruit when treated by new process. *Food Inds.*, **16**, 701 (1944).
16. Tressler, D. K. Ideal temperatures for storing frozen foods. *Ice Cream Field*, **4**, 74 (April 1946).
17. U. S. National Bureau of Standards. *Tables of the Binomial Probability Distribution Applied Mathematics.* Series No. 6 (1950).
18. Van Arsdel, W. B. Time-temperature tolerance of frozen foods. I. Introduction—the problem and the attack. *Food Technol.*, **11**, 28 (1957).
19. Woodroof, J. G., Shelor, Ethyl, Cecil, S. R., and Atkinson, Ida. Preparation of peaches for freezing. Georgia Experiment Station Bulletin 251 (April 1947).

The Time-Temperature Tolerance of Frozen Foods. III. Effectiveness of Vacuum, Oxygen Removal, and Mild Heat in Controlling Browning in Frozen Peaches

D. G. Guadagni and C. C. Nimmo
Western Utilization Research Branch, Agricultural Research Service, United States Department of Agriculture, Albany 10, California

(Manuscript received August 18, 1956)

DURING THE PAST 25 YEARS considerable work has been devoted to the processing of freestone peaches for freezing preservation. In 1947 Woodroof and coworkers *(8)* thoroughly reviewed the more important contributions of earlier workers to peach freezing and presented the results of their own investigations over a period of 16 years. The establishment of 0° F. as a satisfactory storage temperature and the introduction of ascorbic acid as an inhibitor of enzymatic browning were certainly among the most significant developments for the improvement of frozen peaches.

In the first article of this series Van Arsdel *(7)* has pointed out the need for more information on quality deterioration as affected by the temperature experiences encountered during distribution of frozen foods. A comprehensive survey of temperatures during transporation, storage, and distribution was recently conducted by Munter, Byrne, and Dykstra *(4)*. These studies indicate that temperatures as high as 40° F. may be encountered in certain segments of the distribution system. Examination of hundreds of commercially and experimentally packed frozen peach samples exposed to temperatures in the 10° to 30° F. range for varying times has repeatedly shown that enzymic browning or oxidation of the slices exposed to headspace atmosphere is the most important single factor affecting stability of this product *(1, 2)*. In view of the common occurrence of temperatures above 0° F. during transportation and retailing of frozen foods, and in accordance with objectives set forth by Van Arsdel *(7)* this paper deals with methods of preventing or minimizing headspace oxidation in frozen peaches. Although the mild heat treatments described are effective in prolonging color retention after thawing and exposure to atmosphere, control of browning in thawed peaches falls into a separate phase of the problem and requires further research.

MATERIALS AND METHODS

The peaches used were the Elberta variety grown in California and Washington during the 1953 and 1954 seasons. The fruit was firm ripe at harvest, and ripening was allowed to continue at room temperature for 4 to 5 days. The peaches were then sorted, halved, pitted, and steamed (cups down) for 45 seconds at 212° F. After water-spray cooling the skins were slipped off, and the halves were sliced into sixths. The slices were packed in waxed 12-oz. composite-type containers, in enameled 10-oz. tins, and in enameled No. 2 tins. All fruit was packed in 50% sucrose sirup containing 0.1% ascorbic acid unless otherwise specified. For the 10-oz. containers 7.4 oz. of slices were placed in the can containing sufficient sirup to overflow when headspaced to 1/32 inch. The No. 2 cans were filled with 14 oz. of fruit and enough sirup to give a half-inch headspace. The composite cartons contained 8.7 oz. of fruit in sufficient sirup to give a quarter-inch headspace.

Effect of vacuum was determined in the 10-oz. containers by sealing the cans without vacuum and with 10, 20, 25, and 29 inches. The vacuum in each container was also checked after the cans had been frozen and thawed.

Effect of removal of oxygen in the headspace was also determined by adding various amounts of a glucose oxidase enzyme preparation to the Washington peaches packed in No. 2 cans. The enzyme preparation was an all-soluble powder consisting of glucose oxidase and catalase with a reported activity of 1,500 glucose oxidase units per gram. Use of a similar enzyme preparation for the removal of oxygen from apple wine was recently reported *(9)*. In this instance the sirup composition was 45% sucrose and 5% glucose, which provided an excess of substrate for the enzyme, based on the oxygen content in the headspace of a No. 2 can. The enzyme preparation was prepared as a water slurry and applied as follows:

(a) Various amounts were dissolved in sirup containing 0.1% ascorbic acid and added to the fruit in No. 2 cans. After sealing the cans were agitated by hand for 2 minutes and immediately placed in the freezer.

(b) Same as (a) except that no ascorbic acid was added to the sirup.

(c) Same as (a) except that the cans were held at room temperature 3 hours prior to freezing.

(d) After the cans were filled with fruit and sirup, the enzyme preparation was sprayed on the surface of the contents. After sealing, part of the cans were placed in the freezer immediately and the remainder were held at room temperature 3 hours prior to freezing. The percentage of oxygen in the headspace of the sealed containers was determined with a Beckman oxygen analyzer.

Surface inactivation of the polyphenol oxidase enzyme in the fruit tissue was accomplished by various heat treatments. In this experiment, various amounts of ascorbic acid in water were added to the slices in both 10-oz. and No. 2 cans, and then the fruit was covered with 50% sucrose sirup at a temperature of 200° to 210° F. Some of the cans were sealed and cooled in running water without further heat treatment, while others were steam exhausted for various times prior to sealing and cooling. After "hot sirup filling" and sealing, some of the cans were given additional heat treatments in a boiling-water bath.

All samples were frozen in a —20° F. air blast and held at this temperature 4 to 6 months before the stability experiments were initiated. Samples from all treatments were then stored at 20°, 25°, and 30° F. for various periods and subsequently examined for changes in color, soluble solids, and ascorbic acid content.

Evaluation. To insure uniform thawing, all stored samples were cooled to —20° F. prior to defrosting for 2 hours in running water at 60° F. The thawed samples were drained on an 8-mesh screen for 2 minutes and ascorbic acid was determined on an aliquot of the drained sirup-juice mixture by the method of Loeffler and Ponting *(3)*. Browning of slices exposed to headspace atmosphere was assessed in 2 ways: First, all noticeably discolored slices in each container were counted and recorded as brown slices, and second, the degree of browning in these discolored slices was estimated with a Hunter Color Difference Meter. The reference standard used for peaches was a visually matched NBS SBC-35 tile with the following values: Rd = 54.0; a = 1.0; b = 32.0. The slices were placed in round optically matched viewing dishes, and the readings from 2 to 4 packages were averaged.

Soluble solids in the drained fruit were determined on the homogenized slices by refractometer and expressed as percent sucrose. Hot-sirup-filled samples were organoleptically evaluated against cold-sirup controls by a panel of 10 to 13 trained judges, using the triangle taste test. The probability values for the results obtained with this test were taken from *Tables of the Binomial Probability Distribution (6)*.

RESULTS

Effect of container. From previous experience with experimental packs and commercial samples of frozen peaches, color retention in composite containers has been entirely satisfactory as long as the storage temperature was maintained at 0° F. or lower *(1, 2)*. Unfortunately, this type of container is nonhermetic, and therefore a certain amount of exchange of gases between the container and outside atmosphere takes place. Under these conditions browning of slices exposed to headspace atmosphere and container walls occurs in a relatively short time and proceeds at a rapid rate as the temperature is raised from 0° F. to 20° to 30° F. This "breathing" action constantly supplies additional oxygen to the fruit from the outside atmosphere. This oxygen, and also the increase in temperature, causes the polyphenol oxidase in the fruit tissue to oxidize the naturally occurring tannins to brown-black substances. In hermetic containers such as tin cans, however, little or no exchange of gases takes place and browning is limited by the oxygen originally sealed in the container.

The relative rates of browning as measured by numbers of brown slices per package are shown in Figure 1. As shown by the curves for the two types of containers, there was very little increase in number of brown slices in the tin can even after 15 to 20 days at 25° F., whereas in the composite container there was a very sharp increase in brown slices after 5 to 10 days at this temperature. In the enameled can browning was confined to slices exposed to the headspace alone, but in the composite container, even the slices against the walls of the container became discolored on prolonged storage.

Figure 2 also demonstrates the superiority of hermetic containers in protection against oxidation. For the enameled can there was a very small initial loss of ascorbic acid, followed by a leveling off with little or no additional oxidation of this acid during continued storage at 25° F. Once again this indicates that oxidation in the hermetic container is limited by the amount of oxygen originally sealed in the can and when most of this oxygen is used up, little or no additional oxidation takes place. On the other hand ascorbic acid in the composite container is oxidized in a linear fashion until

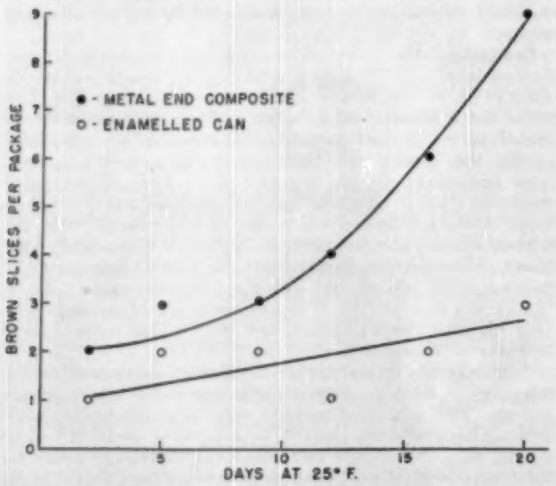


Figure 1. Effect of container on incidence of browning in frozen sliced peaches.

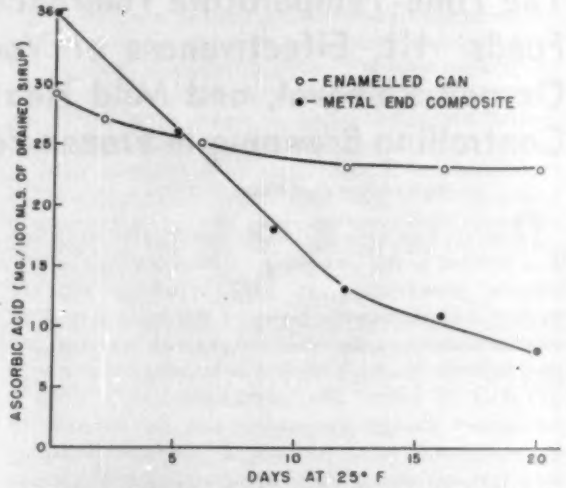


Figure 2. Effect of container on ascorbic acid retention in frozen sliced peaches.

most of the vitamin is lost, indicating a continual supply of oxygen. After 2 weeks at 25° F. the retention of ascorbic acid in the drained sirup was approximately 33% for the composite and 82% for the hermetic container. Thus, in addition to limiting discoloration under adverse temperatures, enameled tins also retain ascorbic acid in the reduced form remarkably well.

Since the number of brown slices in a hermetic container does not change a great deal during storage at elevated temperatures, it was necessary to measure the intensity or degree of discoloration in order to obtain a measure of the effectiveness of vacuum packing. It was observed that decreasing Hunter *Rd* and *b* values correlated rather well with increasing intensity of browning in the yellow-fleshed peaches used in these experiments, and therefore the *b* value was taken as a measure of the degree of discoloration. Since the *b* value measures the relative yellowness of a sample, a high *b* value indicates a bright yellow flesh color while a low *b* reading indicates (in these experiments) a dark brown color. The decrease in *b* value is not particularly due to a loss in yellow pigment but occurs as a result of masking or "covering up" of yellow color by the brown-black oxidation products of the natural peach tannins.

Figure 3 shows the rate of color change during storage at 20° F. as a function of degree of vacuum. The figures represent vacuum gage readings on the thawed cans rather than gage readings at time of sealing. It is clear that samples with 15 or more inches of vacuum showed no significant discoloration throughout the 6-weeks storage. In samples with 8 inches of vacuum sufficient oxygen remained in the container to cause severe browning of slices exposed to headspace atmosphere. However, it is apparent that even 8 inches of vacuum caused a reduction in rate as well as total amount of discoloration when compared to samples packed without vacuum. It is also interesting to note that even though the number of brown slices in hermetic containers remains fairly constant, the *degree* or *intensity* of discoloration in these slices changes markedly between one and four weeks of storage at 20° F. While 15 inches of vacuum appears sufficient to prevent browning under these time-temperature conditions, it

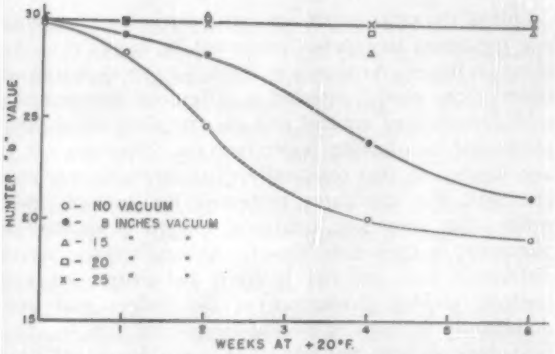


Figure 3. Effect of vacuum packing on rate of color change in frozen peaches.

must be emphasized that other varieties of fruit grown in different areas or seasons may require a higher vacuum (less oxygen) to achieve the same results. In this connection, it has been observed that a vacuum of 20 inches or more tends to give the thawed slices a translucent appearance. This change in natural appearance may influence acceptance of the product.

Figure 4 shows the effect of temperature in the 20° to 30° F. range on rate and extent of color change in frozen peaches packed under normal atmosphere and with 15 inches of vacuum. A point of particular interest is the fact that vacuum-packed samples stored at 20° and 25° F. for 4 weeks showed no detectable color change, and those held at 30° F. changed only slightly during the same period. In contrast the air-packed samples changed at a rate roughly proportional to the temperature, and the total color change also increased with increasing temperature. The extremely large difference in rate of color change between 20° and 25° F. is probably due to a change in state as well as an increase in temperature. At 20° F. most of the package content is solid, whereas at 25° F. the sirup is almost completely thawed. Under these conditions any protective sirup film on the exposed slices melts and drains off, thus facilitating diffusion of headspace oxygen to the fruit surfaces.

These data clearly demonstrate the excellent protection afforded by vacuum packing when the product is exposed to severe time-temperature conditions. It is also apparent that in air-packed samples the critical

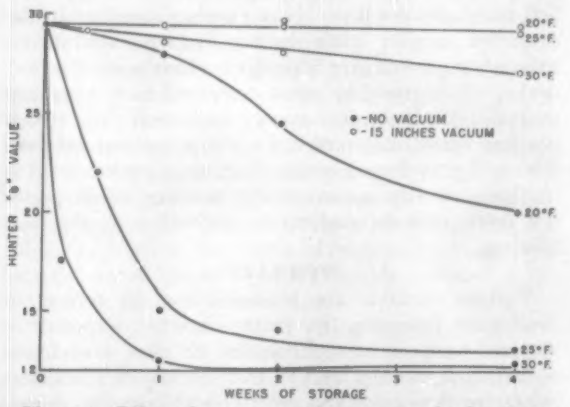


Figure 4. Effect of vacuum packing on rate of color change in frozen peaches.

temperature range with respect to rate of color change lies between 20 and 25° F. Even in hermetic containers, it is very dangerous, from the standpoint of surface discoloration, to allow temperatures above 20° F. for even a few days.

Effect of removal of oxygen with glucose oxidase. The effectiveness of glucose oxidase in removing oxygen from the headspace of a No. 2 can is shown in Table 1. As the content of the enzyme preparation is increased from 0.1 to 2.0 g. per can the percentage of oxygen in the headspace is progressively decreased and consequently the intensity as well as incidence of browning is also decreased. These data indicate that approximately 1 g. per No. 2 can was required to eliminate apparent browning completely during storage at 25° F. for 12 days.

The results above were obtained on samples in which the enzyme preparation was dissolved in the sirup, and no special precautions were taken to allow for reaction at room temperature. When the enzyme slurry was sprayed on the surface of the filled container with care

TABLE 1

Effect of glucose oxidase on browning in frozen peaches stored at 25° F. for 12 days

Treatment	No. of brown slices/can	Hunter b value	% of O_2 in headspace
Control	6	20.9	16.7
0.1 g. oxidase/can[1]	5	21.7	7.3
0.5 g. oxidase/can[1]	2	27.8	2.8
1.0 g. oxidase/can[1]	0	31.6	1.6
2.0 g. oxidase/can[1]	0	33.6	0.4

[1] Reported by manufacturer to have an activity of 1,500 units per gram.

not to invert the can after sealing, approximately 0.5 g. per can was sufficient to prevent browning. With the surface spray, a 3- to 4-hour delay prior to freezing caused no significant difference in color retention, compared to samples frozen without delay. On the other hand, a 3- to 4-hour delay at room temperature increased the efficiency of oxygen removal from cans in which the preparation had been dissolved in the sirup, followed by agitation of the sealed contents. Even after 1.5 months at 25° F. the samples containing 1 to 2 g. of glucose oxidase per can retained their natural yellow flesh color with no evidence of browning.

Slices packed without ascorbic acid, but with glucose oxidase in the sirup, showed significant amounts of discoloration when exposed to headspace atmosphere. Presumably this oxidation took place before the glucose oxidase could lower the oxygen concentration to a sufficiently low level. Apparently ascorbic acid protects the color until the oxidase has used up most of the oxygen, and then the major factor in preventing discoloration under severe time-temperature conditions is simply lack of oxygen. At present, however, it is doubtful that use of glucose oxidase in frozen peaches would be economically feasible.

Effects of various heat treatments. Packing under vacuum or use of oxygen-consuming enzyme preparations effectively controls oxidation in a hermetically closed container, but as soon as the can is opened, enzymatic browning occurs as usual. It is well known that browning can be controlled by conventional heating techniques that destroy enzymes completely. The heat

treatment required for complete inactivation usually causes serious changes in fresh fruit flavor as well as large leaching losses. To overcome these objections relatively mild heat treatments in conjunction with 25 to 100 mg. of ascorbic acid per can were applied to slices by covering with hot sirup (200 to 210° F.), followed by brief steam exhausting (1 to 2 minutes) or sealing, and heating in a boiling water bath for 1 to 3 minutes (Table 2).

TABLE 2

Effect of various heat treatments on browning in frozen peaches stored at 20° F. for 4 weeks

Treatment	No. of brown slices/can	Hunter b value	Soluble solids of fruit[2]
Control, cold sirup	4	18.1	19.0
HSF[1]	4	23.0	23.2
HSF + 1′ water bath 210° F.	3	24.8	23.5
HSF + 3′ water bath 210° F.	0	30.8	24.6
HSF + 1′ steam exhaust	0	30.3	23.8

[1] HSF = hot sirup fill.
[2] Expressed as percent sucrose.

Either a one-minute steam exhaust or a 3-minute boiling-water-bath treatment was necessary to inhibit browning during storage at 20° F. for 4 weeks. Fifty to 100 mg. of ascorbic acid per No. 2 can seemed to be the optimum amount required for best color retention. Even though hot-sirup filling alone was not sufficient to eliminate browning under these time-temperature conditions, the Hunter *b* value indicates considerably better color retention in the hot-filled sample compared to the control. In addition to improved color retention the heat treatments also caused an appreciable increase in the soluble solids of drained slices. As pointed out by Perry and Cruess *(5)* packing fruit in cold sirup and freezing immediately often gives a product with a marked contrast in sweetness between fruit and sirup. This contrast is markedly reduced with the heat treatments used in these experiments, and the thawed product may be more acceptable to those who object to large differences in sweetness.

When hot sirup is added to sliced peaches in a No. 2 can, the center temperature varies between 140° and 150° F., depending on the temperature of peaches and sirup. A one-minute steam exhaust followed by sealing and agitating gives a center temperature in the range of 160° to 165° F. and a 3-minute boiling-water bath treatment gives a temperature of 170° to 175° F.

The principal benefit of heat treatments is improved color retention during exposure of the fruit to atmosphere after thawing. The one-minute steam exhaust retards browning for 6 to 8 hours after complete defrosting, and even after 18 hours' exposure to atmosphere, the heat-treated samples retained their color much better than unheated controls (Table 3).

It is emphasized, however, that these mild heat treatments are not sufficient to cause retention of natural color if the peaches are held at room temperature indefinitely. In addition it should be noted that all the significant improvements in color retention discussed in this paper are associated with use of hermetically closed containers. This type of container allows packing the fruit under conditions which greatly improve the stability of frozen peaches under various time-temperature conditions.

One of the most important considerations in applying any treatment to peaches preserved by freezing is the effect on flavor. As shown in Table 4 a group of trained tasters very easily detected a difference between the cold-sirup-packed control and the hot-sirup-filled sample heated in a boiling water bath for 3 minutes. It is also interesting that practically all judges who correctly identified the duplicates preferred the control, indicating that this heat treatment caused a substantial alteration in fresh-fruit flavor. Although a significant difference was detected between hot-sirup-filled and control samples, preference of the judges was predominantly in favor of the hot-sirup-filled sample. The heat derived from the hot sirup probably caused very little change in natural peach flavor but increased sugar penetration enough to facilitate segregation of the samples on the basis of sweetness differences.

TABLE 3

Effect of various heat treatments on browning of frozen thawed peaches exposed to the atmosphere for 18 hours

Treatment	Hunter color meter readings	
	Rd	*b*
Control, cold sirup	5.2	10.5
HSF[1]	10.2	16.8
HSF + 1′ steam exhaust	19.1	24.1
HSF + 3′ water bath 210° F.	25.2	28.0

[1] HSF = hot sirup fill (200° to 210° F.).

TABLE 4

Effect of various heat treatments on flavor of frozen Elberta peaches

Comparison[1]	No. of judgments	No. who identified duplicates	Probability	Preference	
				Control	Heated[2]
Control vs. HSF	22	12	.03	2	10
Control vs. HSF + 1′ steam exhaust	22	11	.07	4	5
Control vs. HSF + 3′ water bath 210° F.	26	19	.001	16	2

[1] Control was packed in cold 50% sirup and HSF denotes filling with sirup at 200° to 210° F.
[2] Of those who correctly identified duplicates and expressed a preference.

Furthermore, it appears that these particular tasters consider the sugar-acid balance obtained with this treatment preferable to that of the control. Practically the same results were obtained for the comparison between hot-sirup fill plus one-minute steam exhaust and control except for the fact that the judges who correctly identified the duplicates were about evenly divided as to the preferred sample. Both the hot-sirup fill and steam-exhaust treatment give a product which is on the borderline of detectability when compared to a cold-sirup control. Undoubtedly many consumers of frozen peaches would still prefer the sharp contrast between fruit and sirup found in most cold-sirup packs, but it is also possible that a considerable number would prefer the more uniform sweetness obtained with the hot-sirup fill.

SUMMARY

Various methods are presented for the control of headspace browning in frozen peaches exposed to elevated temperatures. Enameled tin cans were found to be much more protective than composite containers with regard to color and ascorbic-acid retention during storage at 20° to 30° F. Color retention was further

improved if the fruit was packed in tins sealed under 15 to 25 inches of vacuum. Fruit packed in this manner retained its original color even after 4 weeks of storage at 20° or 25° F. and changed only slightly during storage at 30° F. for the same length of time. In contrast there was an exceptionally large browning-rate difference between 20° and 25° F. in air-packed samples.

The oxygen in the headspace of No. 2 tins was removed with a glucose oxidase enzyme preparation to an extent which prevented headspace browning during storage at 25° F. for 12 days.

Mild heat treatments designed for only partial inactivation of enzymes were effective in controlling browning during exposure to elevated temperatures. These treatments also prolonged natural color retention after the fruit was thawed and exposed to the atmosphere. These advantages in prolonging color retention can be attained without serious alteration in natural fruit flavor.

Acknowledgment

The authors gratefully acknowledge the cooperation of A. M. Neubert and his staff at the Prosser, Washington, laboratory of this Branch for processing assistance and aid in procurement and selection of some of the fruit used in these experiments. The technical assistance of Miss A. M. Mylne and Mrs. N. J. Downes is also gratefully acknowledged.

LITERATURE CITED

1. Guadagni, D. G., Stithem, Margaret M., and Nimmo, C. C. Factors affecting the degree of browning in frozen peaches stored at 20-28° F. *Quick Frozen Foods*, **16** (11), 46 (1954).
2. Guadagni, D. G., Nimmo, C. C., and Jansen, E. F. Time-temperature tolerance of frozen foods. II. Retail packages of frozen peaches. *Food Technol.*, **11**, 33 (1957).
3. Loeffler, H. J., and Ponting, J. D. Ascorbic acid-rapid determination in fresh, frozen or dehydrated fruits and vegetables. *Ind. Eng. Chem., Anal. Ed.*, **14**, 846 (1942).
4. Munter, A. M., Byrne, C. H., and Dykstra, K. G. A survery of times and temperatures in the transportation, storage and distribution of frozen foods. *Food Technol.*, **7**, 356 (1953).
5. Perry, W. J., and Cruess, W. V. Observations on sugar penetration in frozen fruits. *Quick Frozen Foods*, **15** (11), 55 (1953).
6. U. S. National Bureau of Standards. *Tables of the Binominal Probability Distribution.* Applied Mathematics. Series No. 6 (1950).
7. Van Arsdel, W. B. Time temperature tolerance of frozen foods. I. Introduction—the problem and the attack. *Food Technol.*, **11**, 28 (1957).
8. Woodroof, J. G., Shelor, Ethyl, Cecil, S. R., and Atkinson, Ida. Preparation of peaches for freezing. Georgia Agri. Exp. Sta. *Bull. 251* (1947).
9. Yang, H. Y. Stabilizing apple wine with glucose oxidase. *Food Research*, **20**, 42 (1955).

Organoleptic Wine-Quality Evaluation. I. Standards of Quality and Scoring vs. Rating Scales

F. Filipello
Department of Food Technology, University of California, Davis, California

(Manuscript received May 29, 1956)

Judging for quality by sensory methods has universal employment in the food industry. Furthermore, competitive contests for premium awards are conducted everywhere as an incentive to improve quality.

Organoleptically, the subject of quality in wine resolves itself into three parts; (a) how well the wine conforms to the defined characteristics of the variety in which it is classified, such as Cabernet Sauvignon, Pinot Chardonnay, etc., (b) the absence of defects such as excessive acetic acid, ethyl acetate, acetaldehyde, tannin, etc., and (c) the degree of refinement of the wine, such as careful maturation and cellar treatment and a proper balance of its constituents.

The dependence of general quality upon certain analytical variables has been demonstrated *(3, 4)*. Some minimum detectable concentration differences have been determined for various constituents in wine *(18)*, and these thresholds show a wide range for the various substances, using an average panel of judges. Causative factors directly detrimental to quality are noted *(1)*, such as the action of undesirable yeasts and bacteria, use of excessive sulfur dioxide, cloudiness, inappropriate color, and oxidation.

A primary interest in taste-testing for quality evaluation should be in the development of an absolute taste score and not specifically in comparative scores. In this respect, the problems of the proper weighting of attribute measurements and a uniform scoring system must be overcome or reconciled in some way in order to arrive at a valid, reproducible evaluation. The question of an absolute standard of quality by which all judges can be guided and the concept of the 'perfect' judge has been discussed *(2)*.

It is the purpose of this paper to determine some basis for assessing general quality and to discuss some designs and systems for scoring. In a following paper a comparison will be made between two specific types of panel, and between individual judges, for ability to grade for quality.

EXPERIMENTAL

Test wines. Two groups of wine were used in the study. One group consisted of California Burgundy wine blends as the basis for comparison and evaluation and the other, various California Sherry wine blends.

The Burgundy series evolved from blends of a wine which had won a Gold Medal award at the California State Fair, with a young, commercial Burgundy wine of North Coast origin.

The Sherry group comprised two series; one, quality dilutions of a State Fair Gold Medal award winner with a young, commercial California Sherry wine and the other, dilutions of a fine, dry California Sherry (of somewhat different character than the Gold Medal wine) with the same commercial wine.

Test forms. One form contained the triangular design *(17)* for the determination of differences. The judge was required to choose the odd sample. A second form was used to record which of a pair was preferred. The judge was required to show a preference.

For the determination of the degree of liking for one sample over another in two-sample comparisons, the form given in

Figure 1 was used; a full description and analysis of this type of comparison has been given *(23)*.

Please check below the relative reaction to the two wines.

I prefer sample 1 over sample 2 EXTREMELY	_____
I prefer sample 1 over sample 2 VERY MUCH	_____
I prefer sample 1 over sample 2 MODERATELY	_____
I prefer sample 1 over sample 2 SLIGHTLY	_____
I have no preference	_____
I prefer sample 2 over sample 1 SLIGHTLY	_____
I prefer sample 2 over sample 1 MODERATELY	_____
I prefer sample 2 over sample 1 VERY MUCH	_____
I prefer sample 2 over sample 1 EXTREMELY	_____

Figure 1. Details of form used for paired comparative preferences.

For the grade rating of the test wines, a test form was used which allowed for the rating of as many as 5 samples at a time on a 6-point quality scale, over the range of *top, excellent, very good, good, fair* and *poor*. For analysis, values of 1 to 6 were assigned to these quality grades, beginning with *poor*.

For scoring, a scale of 1 to 20 was used to describe the general quality of a test wine, the score of 20 representing the highest quality possible. The test form allowed for the scoring of as many as 5 samples at a time.

Selection of panel. A panel of 8 members was used for the tests. Four were members of the staff in the Department of Enology; these were closely associated with wine (at least 10 years' experience) and all had been wine judges in premium award tastings at the California State Fair. The remaining four were other staff members and University personnel who were well-acquainted with wine, but had had no experience in judging quality wines.

Serving procedure. The tasting was done in individual, air-conditioned booths. The samples were presented at room temperature, 70-75° F., and the time of presentation was 11 : 30 A.M. About one ounce of wine was served in each glass for tasting. Unsalted crackers and water were made available to each taster for the removal of taste effects between samples. This combination was found very effective with other food items *(5)*.

Randomized presentations were made of samples within each block and of blocks comprising each group. Each block was tasted in the order given.

In the paired preference comparisons, 3 blocks of pairs were presented to each taster, this comprising the group for each daily sitting. For the triangular design, two sets of 3 samples were given. Three blocks of pairs were presented when using the design of Figure 1, the degree of liking for one sample over another. For the rating and scoring tests, one block of 4 or 5 samples, or two blocks of 3 samples were given as the daily group.

Experimental designs and methods. Since an analysis of the results would require some standard of reference, it was believed reasonable to adopt the Gold Medal award wines as the highest grade possible. Dilutions of these wines by blending with the young wines would furnish graded steps decreasing in general quality.

An attempt was made, therefore, to establish a series of grades by means of minimum detectable differences for the panel of judges. Difference thresholds were determined by both the triangular technique and paired comparison for the Burgundy series. Since the quality could not be unambiguously specified in the case of paired comparisons, the question of preference, between the 2 samples, was asked. In this respect, reliance was placed upon the panel that the quality preference would be unidirectional; i.e., that all judges would prefer the blend containing the higher proportion of Gold Medal wine in all cases, when the difference became detectable. The paired preference did prove efficacious in establishing levels of dilution in the quality series.

Each step in grade was determined as follows: when the preference in pairs or the difference in triangular was significant at the 5% level (95% confidence level) between two levels of dilution, this difference was adopted as a significant step in quality grade. For the two designs, sets of statistically definable grades (thresholds of quality difference) were thus established for the Burgundy series. For the Sherry wines, only the grades derived from paired preference were used.

Since the rating and scoring tests would require a comparison of more than 2 samples at a time, the resulting series of grades from the paired preference were submitted to the comparative liking test (Figure 1). These were given in balanced, incomplete blocks, with replications, to obtain an equal number of judgments for all possible arrangements in both orders of serving. This procedure would give a measure of the degree of liking for one level of dilution over another, as compared against all others in the same series.

To reduce the effect of adaptation from prolonged tasting of any one series of wines, the group of wines served (Burgundy or Sherry) was alternated every 3 days, with variations in design.

For the rating and scoring determinations, balanced incomplete blocks were used generally. This design has a psychological advantage; since all samples in any one experiment are never presented at the same time, the design, while giving the tasters enough information to retain their interest, does not give so much information as to prejudice their judging *(16)*.

PRACTICAL CONSIDERATIONS

The basic assumptions of the analysis of variance are *(11)*: (a) the observations are independently distributed, (b) the observations come from a normal population, (c) the error variances are homogeneous and (d) the treatment and environmental effects are additive. The effect of taste fatigue, discrete scoring scale and adaptation in causing departures from these assumptions have been mentioned *(24)*, although departures from assumption (b) may not be serious *(8)*. The reduction of the number of treatments or the use of incomplete block designs will somewhat alleviate the departures from assumptions (a) and (c), *(9)*. Adaptation effects lead to departures from assumption (d).

Some of the difficulties in rating and scoring deal with non-uniformity of scaling procedure, lack of consistency on the part of the individual judge, lack of agreement as to what is a "true criterion," doubt as to the appropriateness of analyses of variance on scores or ratings and the limitation of observation numbers due to taste fatigue *(6)*.

In this study an attempt was made to minimize the above effects, by the use of incomplete blocks, limited size and number of blocks served and by alternating the wine group and block design presentation. Since the study required over five months to complete, a fairly good estimate of error could be obtained.

RESULTS AND DISCUSSION

Triangular vs. paired preference thresholds. When the triangular design was used, suspiciously high dilutions were required. This is noted in Table 1; only 3 grades were available for the Burgundy series by triangular test, whereas 5 grades were possible by paired preference. On this basis, the thresholds by paired preference were adopted. There is abundant evidence that the triangular design may be less sensitive, in certain cases, than the two-sample comparison *(7, 13, 14, 15)*.

Paired preference vs. paired comparison. The paired preference tests yielded definably quality-different concentrations for the Burgundy and Sherry wines (at the 5% level of significance) as given in Table 1. The grade numbers increase with decreasing quality.

The grades for each series, obtained by paired preference, were submitted to the two-sample test design of Figure 1 and analyzed by a method of paired comparison *(23)*. This method allows for the effect of all other grades in a series upon the degree of liking for any one. The presentation was given in randomized, balanced incomplete blocks. For the 5 grades of Burgundy wine, 6 replications were given. All 8 Sherry wine blends were used in the design in two replications.

An analysis of variance was made on the panel responses. To test the assumption that the variance of the scores was the same for all ordered pairs, i.e., the homogeneity of variance, Cochran's test *(12)* was applied. This test was used due to the fact that some of the variances were zero and, also, it is very sensitive in detecting lack of homogeneity due to the variance of one set of scores being considerably larger than the variance of the others. No evidence of heterogeneity was noted in the score variances.

The results of the analysis are given in Table 2. There was evidence of a significant (5% level) order

TABLE 1

Wine blends of minimum significantly-different quality

Grade	Burgundy[1]		Sherry[2]	Sherry[3]
	Triangular test	Paired test	Paired test	Paired test
1	100% G.M.	100% G.M.	100% G.M.	100% Sherry
2	60% G.M.	77% G.M.	75% G.M.	75% Sherry
3	20% G.M.	57% G.M.	50% G.M.	50% Sherry
4	.....	35% G.M.	25% G.M.	25% Sherry
5		10% G.M.	.....	.....

G.M. = Gold Medal wine.
[1] The wine used for blending was a young, commercial Burgundy.
[2] The wine used for blending was a young, commercial Sherry.
[3] The wine used for blending was a young, commercial Sherry—the quality wine was different than that of (2).

TABLE 2

Analysis of variance by paired comparison for Burgundy and Sherry wine blends

	Burgundy			Sherry		
	s.s.	d.f.	m.s.	s.s.	d.f.	m.s.
Main effects	305.28	4		415.67	7	
Deviations from subtractivity	19.87	6	3.31	23.27	21	1.11
Average preferences	325.15	10		438.96	28	
Order effects	34.68	10	3.47*	46.54	28	1.66
Means	359.83	20		485.50	56	
Error	163.17	100	1.63	123.50	56	2.21
Totals	523.00	120		609.00	112	

* Significant at 5% level; tabulated $F_{.05} = 1.92$.

effect in the case of the Burgundy comparisons only, while no significant deviations from subtractivity were noted for any of the comparisons. The hypothesis of subtractivity is analogous to the absence of interaction in a two-way layout and, if the hypothesis is not violated, the interpretation of the main effects becomes clearly due to the difference in means alone. The acceptance of the hypothesis denotes that there are parameters a_1, a_2, a_3 . . . a_n, which characterize each of the n stimuli such that the average preference for one stimulus over another is the difference between the corresponding parameters.

The *a* parameters were calculated; for the five grades of Burgundy, $a_1 = 1.267$, $a_2 = 0.850$, $a_3 = 0.133$, $a_4 = -0.800$ and $a_5 = -1.450$. For the two groups of Sherry wine, $a_6 = 1.531$, $a_7 = 0.969$, $a_8 = -0.844$, $a_9 = -1.781$, $a_{10} = 1.625$, $a_{11} = 0.375$, $a_{12} = -0.563$ and $a_{13} = -1.312$, where a_6 to a_9 represent values for blends of the Gold Medal Sherry and a_{10} to a_{13} the blends of the other high quality Sherry wine. It is to be noted that both undiluted Sherry wines were liked about equally well, as evidenced by the close agreement between the *a* values for the undiluted wines, $a_6 = 1.531$ and $a_{10} = 1.625$.

To test the significance of the difference between any two wines in each series, a "yardstick" of least significant difference is used, defined as

$$Y_e = q'_{1-e}\sqrt{\frac{s_e^2}{2rm}}$$

where s_e^2 = error variance
r = number of judgments in each ordered comparison
m = number of wines
q_{1-e} = Studentized range variable q at a confidence coefficient of 1—e.

If the confidence coefficient is taken as 1—e = 0.95, for the Burgundy wines the error degrees of freedom are 100 and m = 5, then from tables (20, 21), the value for $q_{0.95} = 3.93$. From Table 2, $s_e^2 = 1.63$ and r = 6, then

$$Y_{0.05} = 3.93\sqrt{\frac{1.63}{2 \times 6 \times 5}} = 0.648$$

Similar calculations for the Sherry group yield, allowing for 56 degrees of freedom for error, m = 8, $s_e^2 = 2.21$, r = 2 and $q_{0.95} = 4.45$,

$$Y_{0.05} = 4.45\sqrt{\frac{2.21}{2 \times 2 \times 8}} = 1.170$$

The differences between adjacent grades and the corresponding yardsticks are given in Table 3. Comparing each group of wine grades with the corresponding *Y*-value, it is noticed that while not all differences in grade are significant at the 5% level, most of the values approach or slightly surpass the significance level. In this respect, the *a*-values themselves are observed to decrease progressively for each lower grade. In the light of the manner by which these experiments were organized, it would appear justifiable to consider these results as a test of a one-sided hypothesis rather than the two-sided test implied by the tabulated *q*-values. The quality in the graded series has been experimentally controlled and the test is that of the

TABLE 3

Differences between adjacent a-values for Burgundy and two groups of Sherry wine

	Difference in a-value		
	Burgundy	Sherry[1]	Sherry[2]
a_1-a_2	.417		
a_2-a_3	.717		
a_3-a_4	.933		
a_4-a_5	.650		
a_6-a_7		.562	
a_7-a_8		1.813	
a_8-a_9		.937	
$a_{10}-a_{11}$			1.250
$a_{11}-a_{12}$			.938
$a_{12}-a_{13}$			.749
$Y_{0.05}$	.648	1.170	1.170

[1] Blends with Gold Medal Sherry.
[2] Blends with second high quality Sherry.

ability for the taster to detect in the proper direction. On this basis, the significance of the differences in a-values would be increased. One- and two-sided tests of hypothesis have been discussed *(10, 22)*.

In general, the two types of paired test demonstrated a definite basis for the existence of a graded series.

Design effects on rating and scoring. Table 4 shows the product-moment correlation coefficients obtained by the panel when different designs were used for the Burgundy series. The usual tests for significance between correlation coefficients could not be used due to the fact that the same panel was operative in all cases and correlation between designs had to be considered. However, Hotelling *(19, 25)* has furnished a solution to this problem, and under this test, there is evidence of a significant difference between the 3-sample ($r = .70$) and the 4-sample ($r = .60$) incomplete block presentations by the rating method. Also, the 5-sample design, which was alternately served as a 5-grade complete block or a 4-grade + 1 blind control series, showed that there was a significantly better correlation for the complete block of 5 grades ($r = .75$) over the 4 grades + 1 blind control ($r = .59$). This demonstrates the tendency for the panel to rate each sample in the block as a different grade from any other.

TABLE 4
Product-moment correlation coefficients for Burgundy using various designs

	Number of judgments	Correlation coefficient
Rating scale		
Incomplete blocks		
3-sample	187	.70
4-sample	187	.60
Complete blocks		
5 grades	150	.75
4 grades + 1 control	150	.59
Scoring scale		
Incomplete blocks		
3-sample	142	.72
4-sample	142	.74

TABLE 5
Correlation coefficients by rating and scoring scales for two series of Sherry blends

	3-sample incomplete blocks	
	Rating	Scoring
Sherry[1]	.68	.44
Sherry[2]	.70	.51

[1] Series derived from Gold Medal Sherry.
[2] Series derived from second high quality Sherry.

When scoring the Burgundy series in incomplete blocks of 3 or 4 samples, in a scoring range of 1 to 20, there was no significant difference in correlation between the two types of block.

To determine the effect of the presence of more than one wine of the same quality grade in the same block, a series of Sherry blends was given to the panel. These were randomized, incomplete blocks of 3 samples drawn from the 4 grades of Gold Medal Sherry and the 4 grades of the second high quality Sherry wine. The comparison of one wine with any other was made possible. In Table 5 are given the correlation coefficients for each group of Sherry blends, using the rating and scoring scales identical to those used for the Burgundy series. Both methods revealed a significant linear relationship between grade and type of scoring. However, rating was significantly better than scoring for both series of Sherry wine blends. The presence of two grades of identical quality in the block tends to affect the correlation in the scoring method.

SUMMARY

Standards for quality were established by paired preference comparison. Using Burgundy and Sherry wines of defined quality, grades in quality were produced in terms of thresholds of quality difference.

A paired comparison analysis was used to substantiate the results derived from the paired preference study.

In the Burgundy series, incomplete block presentations of 3 samples yielded significantly higher correlation coefficients than 4 samples when used with a rating method.

The panel showed a tendency to rate each sample in the block as different from any other sample.

When more than one wine of the same quality grade was present in the block, there was a significantly better correlation using the rating as compared with the scoring method.

Acknowledgment

Funds for this study were made available through contract with the Wine Advisory Board. Appreciation is expressed for the patient and enthusiastic cooperation of the panel members.

LITERATURE CITED

1. Amerine, M. A., and Joslyn, M. A. *Table Wines.* 1951. University of California Press, Berkeley, Calif.
2. Amerine, M. A., and Roessler, E. B. Techniques and problems in the organoleptic examination of wines. *Proc. Am. Soc. Enol.*, **3**, 97-115 (1952).
3. Baker, G. A., and Amerine, M. A. Organoleptic ratings of wines estimated from analytical data. *Food Research*, **18**, 381-389 (1953).
4. Baker, G. A. Organoleptic ratings and analytical data for wines analyzed into orthogonal factors. *Food Research*, **19**, 575-580 (1954).
5. Baten, W. D. Materials for removing taste effects in organoleptic tests. *J. Home Econ.*, **39**, 30-32 (1947).
6. Bradley, R. A. Some statistical methods in taste testing and quality control. *Biometrics*, **9**, 22-38 (1953).
7. Byer, A. J., and Abrams, D. A comparison of the triangular and two-sample taste-test methods. *Food Technol.*, **7**, 185-187 (1953).
8. Cochran, W. G. Some consequences when the assumptions for the analysis of variance are not satisfied. *Biometrics*, **3**, 22-38 (1947).
9. Cox, Gertrude M. Statistics as a tool for research. *J. Home Econ.*, **36**, 575 (1944).
10. Edwards, Allen L. *Statistical Methods for the Behavioral Sciences.* 1954. Rinehart and Co., Inc., New York, N. Y.
11. Eisenhart, C. The assumptions underlying the analysis of variance. *Biometrics*, **3**, 1 (1947).
12. Eisenhart, C., Hastay, M. W., and Wallis, W. A. *Techniques of Statistical Analysis.* 1947. McGraw-Hill Book Co., Inc., N. Y.
13. Filipello, Ferrer. Small panel taste testing of wine. *Am. J. Enol.*, **6**, 26-32 (1955).
14. Filipello, F. A. A critical comparison of the two-sample and triangular binomial designs. *Food Research*, **21**, 235-241 (1956).
15. Gridgeman, N. T. Taste comparisons—two or three? *Food Technol.*, **9**, 148-150 (1955).
16. Hanson, Helen L., Kline, Leo, and Lineweaver, Hans. Application of balanced incomplete block design to scoring of ten dried egg samples. *Food Technol.*, **5**, 9-13 (1951).
17. Helm, E., and Trolle, B. Selection of a taste panel. *Wallerstein Lab. Commun.*, **9**, 181-194 (1946).

18. Hinreiner, Elly, Filipello, F., Berg, H. W., and Webb, A. D. Evaluation of thresholds and minimum difference concentrations for various constituents of wines. IV. Detectable differences in wine. *Food Technol.*, **9**, 489-490 (1955).
19. Hotelling, Harold. The selection of variates for use in prediction, with some comments on the general problem of nuisance parameters. *Annals Math. Stat.*, **11**, 271-283 (1940).
20. Newman, D. The distribution of ranges in samples from a normal population expressed in terms of an independent estimate of the standard deviation. *Biometrika*, **31**, 20 (1940).
21. Pearson, E. S., and Hartley, H. O. Tables of the probability integral of the studentized range. *Biometrika*, **33**, 89 (1943).
22. Roessler, E. B., Baker, G. A., and Amerine, M. A. One-tailed and two-tailed tests in organoleptic comparisons. *Food Research*, **21**, 117-121 (1956).
23. Scheffé, Henry. An analysis of variance for paired comparisons. *J. Am. Stat. Assn.*, **47**, 381-400 (1952).
24. Terry, M. E., Bradley, R. A., and Davis, L. L. New designs and techniques for organoleptic testing. *Food Technol.*, **6**, 250-254 (1952).
25. Walker, Helen M., and Lev, Joseph. Statistical Inference. 1953. Henry Holt and Co., Inc., New York, N. Y.

Organoleptic Wine-Quality Evaluation. II. Performance of Judges.

F. Filipello
Department of Food Technology, University of California, Davis, California

(Manuscript received May 29, 1956)

The difficulties in rating and scoring, apart from the vagaries of the judges as individuals, have been discussed in the preceding section of this paper *(1)*. In this portion of the study, a comparison will be made between two specific types of panel, and between individual judges, for ability to grade for quality.

Techniques for organizing small tasting panels have not been well standardized. The members of the panel are frequently selected for their interest or their availability, rather than for the acuity of their senses of taste and smell *(3)*. The evaluation of food-tasting scores to determine whether a person is a good judge involves finding (a) whether the judge can discriminate among foods of the same kind and (b) whether he can duplicate his own judgments.

EXPERIMENTAL

Test forms. For the rating of the test wines, a test form was used which allowed for the rating of as many as 5 samples at a time on a 6-point quality scale, over the range of *top, excellent, very good, good, fair* and *poor*. For analysis, values of 1 to 6 were assigned to these quality grades, beginning with *top*.

For scoring, a scale of 1 to 20 was used to describe the general quality of a test wine. The score of 20 represented the highest quality possible. The test form allowed for the scoring of as many as 5 samples at a time.

Panel. Two panels were operated concurrently. One panel consisted of 4 members of the Enology staff in the Department of viticulture who had had wide experience with quality wines and had been members of wine-judging committees at the California State Fair. This panel was denoted the panel of wine-judges. The other panel was termed non-judges, to differentiate them from the wine-judges; they had had no wine-judging experience, although they were well acquainted with wines. This latter panel consisted of 4 members also.

Test wines. The test wines used were blends of a California State Fair Gold Medal Burgundy wine. The manner in which the quality blends were derived has been described in the previous section of this paper *(1)*.

Experimental designs. The tested Burgundy wines were served in single sample presentations, incomplete blocks of 3 or 4 samples, complete blocks of 5 samples and presentations of 5 samples containing 4 different grades plus one blind control.

RESULTS AND DISCUSSION

Performance: wine-judges vs. non-judges. Table 1 shows, for each panel, the product-moment correlation coefficients for the relationship of the rating and scoring scales to the graded series of 5 Burgundy wines.

TABLE 1
Panel correlation coefficients for Burgundy series

	Wine-judges		Non-judges	
	N	Corr. coef.	N	Corr. coef.
Rating scale				
Incomplete blocks				
1 sample	26	.26	27	0
3-sample	100	.83	90	.65
4-sample	100	.77	90	.44
Complete blocks				
5 grades	80	.80	75	.72
4 grades + 1 blind control	80	.70	75	.50
Scoring scale				
Incomplete blocks				
3-sample	70	.82	70	.46
4-sample	70	.84	70	.50

Even though both panels demonstrated significant correlations for rating and scoring with grade, the panel of wine-judges was significantly better than that of non-judges. The test used for the significance of the difference between coefficients of the 2 panels, was based upon Fisher's transformation *(4)*. The wine-judges were better than the non-judges when 3- or 4-sample incomplete blocks were rated or scored and also when 4 grades plus 1 blind control were served. When the complete block of 5 samples was served, no significant difference was observed between panels.

A number of other pertinent observations are available from Table 1. The first is revealed in a comparison of the correlation coefficients when complete blocks are served (5 grades vs. 4 grades plus 1 blind control). Both the wine-judges and non-judges showed a significant difference in correlation between the two designs. The test of significance employed was that of Hotelling *(2, 4)*, which allows for intra-panel correlation between designs. The judges were cognizant that 5 grades of wine existed and showed a significant tendency to grade the 5 samples on this basis, even though they knew that the designs were being randomized.

The second observation is that there was significant improvement by both panels in rating 3 samples in incomplete blocks over 4 samples, even though 2 sets of 3 samples were served at a sitting, for a total of 6 samples, as against 1 set of 4 samples. This may be evidence of a psychological factor whereby the fatigue effect is reduced by the serving of small blocks, although the total number of samples served, by replication, may

exceed the number served in a larger block. The scoring scale did not exhibit this phenomenon.

The final point noted is that there is insignificant correlation when only a single sample is rated; for wine-judges $r = .26$, and non-judges $r = 0$. Having no immediate comparison available, the judge's memory provides a poor measure of standards of quality.

Performance of individual judges. The fact that a judge demonstrates a high degree of association between the rating and the quality grade, as measured by the correlation coefficient, does not necessarily prove him to be a highly discriminating judge. In Table 2 are

TABLE 2
Correlation coefficients for each judge for Burgundy series
Design: blocks of 3 samples
Judgments per judge = 30

Taster	Wine-judges				Non-judges			
	A	B	C	D	E	F	G	H
Correlation coefficient	.87	.90	.87	.82	.78	.58	.58	—[1]

[1] Taster H was not available for these tests.

given correlations for each judge of the two panels, based upon rating data obtained from the 3 sample incomplete block series. All of the wine-judges demonstrated high degrees of correlation, (r over .80), without seeming differences between these judges. However, plots of lines of linear regression for each of these judges, shown in Figure 1, revealed significant differences in performance. The rating scale was assigned quality values from 1 to 6, beginning with *top*. In this figure, a theoretical line has been added to indicate a perfect correlation, in all respects, between the identifiable grade and the rating scale. In terms of the slopes of the lines, the responses for judges A, B, and C did not deviate significantly from that of the theoretical. This would signify that these tasters did establish

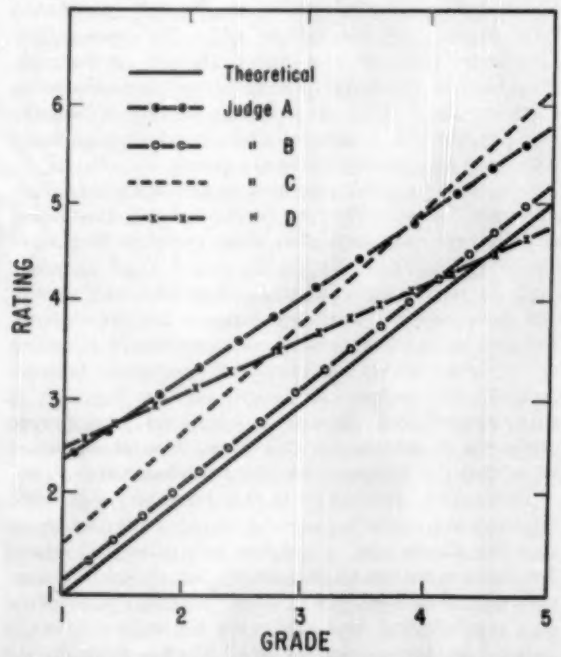


Figure 1. Lines of linear regression for judges A, B, C and D in 3 sample Burgundy series.

a rating for each grade, disregarding the fact that judge A may have been more critical in judging the wine of best quality. From the ordinate intercepts, judges B and C did not reveal significant differences from the theoretical; these two tasters were in agreement with the theoretical grade ratings. The result of this analysis would be that taster B is the best by this method of rating, C is a close second, A is somewhat critical of the best quality wine, whereas judge D demonstrates a significantly conservative tendency; i.e., to confine the grades into a smaller number of ratings.

Effect of serving order. An analysis for the order effect revealed no significant differences due to positional order when the rating scale was used with incomplete blocks of 3 or 4 samples. Very significant effects were noted in using the scoring scale. Table 3 gives an analysis of variance for both rating and scoring for each panel. While the rating scale was found insensitive to serving order for either panel, the scoring scale showed effects of order, both panels being so affected in the case of 4 sample blocks and the non-judges in the case of the 3 sample presentation. Also, there was a significant interaction, which denoted a differential order effect by grades.

TABLE 3
Analysis of variance for order effect on serving incomplete blocks of 3 and 4 samples

	Rating scale							
	3-sample				4-sample			
	Wine-judges		Non-judges		Wine-judges		Non-judges	
	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.
Order effect	2	.21	2	.07	3	.34	3	.31
Grades	4	5.39***	4	3.03***	4	7.09***	4	2.40***
Order X Grades	8	.13	8	.13	12	.21	12	.66
Error	105	.10	83	.25	60	.30	72	.49
	Scoring scale							
	3-sample				4-sample			
	Wine-judges		Non-judges		Wine-judges		Non-judges	
	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.
Order effect	2	.80	2	6.80*	3	4.66***	3	13.62***
Grades	4	65.20***	4	22.99***	4	52.22***	4	37.61***
Order X Grades	8	1.36	8	5.03*	12	16.64***	12	5.11***
Error	63	1.93	75	2.18	44	.39	33	.44

d.f. = degrees of freedom.
m.s. = mean square.
* = significant at 5% level.
*** = significant at 0.1% level.

This order effect was suspected as being due to the sensitivity of the extended scoring scale rather than the order effect due to grades. When the scoring scale was transformed into a range of five ratings, 17-20 for rating 1, 13-16 for rating 2, 9-12 for rating 3, 5-8 for rating 4 and 0-4 for rating 5, the order effect disappeared in the case of the wine-judges, whereas it still persisted for the non-judges.

Block effects. The effect of the particular combination of wines within a block was tested and found to be non-existent for the Burgundy wines tested, when the rating scale was used.

Since the 3-sample incomplete blocks were served in two sets at any one sitting, the difference in response between the first and second set was analyzed. No significant differences in correlation were noted between sets, and it would be concluded that no fatigue effect

could be demonstrated in tasting these two sets of Burgundy wines.

For the rating scale, in this study, a balancing of blocks for comparison and order would not appear essential. Fewer replications could be used without fear of bias.

SUMMARY

Two panels, one of wine-judges and the other non-judges, were able to rate and score to a significant degree a series of quality-different Burgundy wine blends. The wine-judges were significantly better than the non-judges in grading the wines.

Differences were noted in the performance by individual judges, even though correlation coefficients were high for each person.

For the rating scale, incomplete blocks of three samples yielded higher correlation coefficients than for blocks of four samples. When single sample presentations were made, neither panel showed any significant degree of correlation to grade.

No significant order effect was noted in rating incomplete blocks of three or four samples; for scoring, a highly significant order effect was present.

LITERATURE CITED

1. Filipello, F. Organoleptic wine-quality evaluation. I. Standards of quality and scoring vs. rating scales. *Food Technol.* (This issue).
2. Hotelling, Harold. The selection of variates for use in prediction, with some comments on the general problem of nuisance parameters. *Annals Math., Stat.*, 11, 271-283 (1940).
3. Overman, Andrea, and Li, Jerome, C. R. Dependability of food judges as indicated by an analysis of scores of a food-tasting panel. *Food Research*, 13, 441-449 (1948).
4. Walker, Helen M., and Lev, Joseph. *Statistical Inference*. 1953, Henry Holt and Co., Inc., New York, N. Y.

Characterization of Volatile Nitrogen and Volatile Sulfur Fractions of Cooked Chicken and Their Relation to Flavor[a]

E. L. Pippen and E. J. Eyring
Western Utilization Research Branch, Agricultural Research Service, United States Department of Agriculture, Albany 10, California

(Manuscript received June 14, 1956)

Characterization of the volatile components and determination of their contribution to flavor is an important part of any flavor study. Reports in the literature concerning the chemical nature of meat flavor are relatively scant, but emphasize the importance of volatile components. Crocker *(6)* concluded that cooked meat flavor is attributable primarily to its aroma. He identified hydrogen sulfide in the volatile fraction of cooked beef and postulated the presence of other acids and nitrogen-containing substances. Bouthilet *(2, 3, 4, 5)* in a series of articles on chicken flavor demonstrated presence of ammonia and hydrogen sulfide in chicken broth distillate and obtained results suggesting presence of a sulfur-containing organic compound of importance to chicken flavor. Objectives of the work reported here were to enlarge on these findings by completing characterization of volatile nitrogen and volatile sulfur fractions of cooked chicken, to develop quantitative methods for their determination, and evaluate their importance to volatile flavor.

EXPERIMENTAL

Source and processing of chickens. Chickens used in this study were old hens obtained in the live state from a commercial source. They were processed to the ready-to-cook point at this laboratory, bagged in polyethylene and held at —10° F. until needed.

Chicken broth. In this study unseasoned chicken broth was obtained from both a commercial source and from batches prepared at this laboratory. That from the commercial source was received in tin containers in the frozen state and kept at —20° F. until used. When thawed, rough separation of fat and aqueous phases was accomplished with a separatory funnel. Unless otherwise specified only the aqueous phase was used. The commercial broth contained 0.4% solids (W/V) and was used exclusively for chemical experiments. At this laboratory broth was prepared and worked up as described in a previous publication *(11)*. It was used for both chemical and organoleptic studies.

Distillation. Distillations at both atmospheric pressure and under vacuum were used in this study to effect a separation of volatile flavor. The former method was used to obtain distillate for chemical investigations. It was carried out in an all-glass apparatus. Heating was accomplished with a gas flame and condensation by passing the distillate through a tap-water-cooled condenser. Condensate was collected and stored in glass bottles. To prepare broth concentrates and volatile fractions for organoleptic evaluation, distillation *in vacuo* was carried out with an apparatus similar (except no preheater was used) to that described by Dimick and Makower *(7)*. All parts of the apparatus coming in contact with the broth, the concentrate, or the condensate were constructed of glass. Concentrated broth was collected during distillation in a flask immersed in ice water. Condensation was accomplished by an ice-water-cooled condenser and a series of progressively colder traps ending in a dry ice-alcohol trap. When the condensate from this vacuum distillation was used to reconstitute broth concentrate, contents of all receivers of condensate were first pooled and mixed to insure a homogeneous condensate.

Flavor evaluation. Determination of relative intensity of chicken flavor and odor present in broth samples was accomplished with a taste panel. Flavor and odor, for purposes of this study, are defined as previously described *(11)*. Samples were ranked for intensity of either chicken flavor or odor, with a rank of 1 for the sample having most intense chicken flavor or odor, 2 for the next most intense, etc. Unless otherwise specified, the details of serving broth samples for taste panel evaluations are the same as described in an earlier study *(11)*. Significance of results was determined by appropriate methods of analysis *(15)*.

Preparation of broth samples for taste-panel evaluation. In 1.5 hours, 4.2 liters of chicken broth was stripped by vacuum distillation of 48.4% of its weight. The concentrate was stirred and divided into two equal portions. One portion was diluted to original volume with distilled water; the other was similarly diluted with the condensate. Reconstituted broth samples were then placed in tins and held at —20° F. until evaluated.

Broth distillate was first prepared by distilling, at atmospheric pressure, 87% of the weight from 4.2 liters of chicken broth. Condensate was stored overnight at 4° C. The following day the distillate was divided into 2 portions. The smaller portion was held at 4° C.; the other, 2.2 liters, was passed, at a

[a] Presented at the Sixteenth Annual Meeting of Institute of Food Technologists, June 12, 1956, St. Louis, Mo.

rate of 7.5 ml./min., through a freshly regenerated, freshly washed column (2.5 cm. x 50 cm.) of Dowex 50 in the hydrogen cycle. The first 200 ml. of liquid emerging from the column was discarded, and the remainder collected in an ice-water-cooled flask. After about 2 liters of liquid was collected, the process was interrupted and the decationized distillate stored at 4° C. The following day, 6.30 liters of broth (from the same lot used to prepare distillate described above) was stripped *in vacuo* of 58.2% of its weight in a 3.5-hour run. Concentrate was mixed, divided into two 1300-g. portions, and promptly reconstituted. One portion of the concentrate was reconstituted with 1300 ml. of the unfractionated distillate; the other with 1300 ml. of the resin-treated distillate. Reconstitued broth was sealed in tins and held at —20° F. until evaluated.

Reducing values of distillate. Reducing values of the distillate and fractions thereof were determined by oxidation with alkaline permanganate by adapting the procedure of Friedmann and Klaas *(8)*. The oxidizing mixture used in this study consisted of a mixture of 20.0 ml. of the sample, 25 ml. of distilled water, 10 ml. of 5 *N* NaOH, and 5 ml. of 0.1 *N* $KMnO_4$. Titration of iodine, liberated by permanganate remaining after oxidation, was done with 0.05 *N* thiosulfate. Blanks were run with each series of determinations. Results were expressed as microequivalents of reduction per milliliter of sample.

Determination of sulfide sulfur in broth distillate. Hydrogen sulfide present in distillate of chicken broth was determined by the methylene blue method, which is specific for sulfide sulfur. Conditions used were those described by Sands and co-workers *(13)*. An aliquot of broth distillate of size sufficient to contain 10 to 35 mcg. of H_2S (usually 10 to 20 ml.) was pipetted into 5.0 ml. of 20% zinc acetate solution. The resulting solution was diluted to 50.0 ml. and color was developed as described in the reference cited above. Optical density was read on the Coleman Model II Universal Spectrophotometer at 680 mμ. The amount of H_2S present was then determined from a standard curve prepared from a plot of known amounts of H_2S in 50 ml. versus optical density of the subsequently developed methylene blue color.

Total sulfur. Total sulfur was determined gravimetrically as barium sulfate after oxidation of the sample with alkaline permanganate For determination of sulfur present at a concentration of a few p.p.m. in water (as is the case with broth distillate) the method of Potter and Jones *(12)* was adapted as follows. To the portion being analyzed (often one to two liters in this study) was added 0.5 ml. of saturated aqueous NaOH and 5 to 10 ml. of saturated aqueous $KMnO_4$. The solution was brought to boiling, evaporated to about 30 ml. and then transferred, with conc. HCl rinses to a 100-ml. evaporating dish. From this point on the procedure mentioned in the above-cited reference was followed.

Isolation and characterization of volatile nitrogen. Chicken broth, 4.4 kg., was distilled until 4.2 liters of distillate were obtained. The distillate was passed through a column of Dowex 50 (2.2 cm. x 28 cm.) which had been previously treated with 1 *N* HCl followed by thorough water washing. This results in quantitative removal of nitrogen from the distillate as will be shown in subsequent results. Nitrogen absorbed on the resin was then eluted with 1 *N* HCl (200 ml.). Evaporation of the eluate to near dryness yielded a crystalline residue which was stored in a desiccator over $CaCl_2$ and dry NaOH until free from moisture and residual HCl. Yield of the dry residue was 0.39 g. When a portion of it was moistened with sodium hydroxide, odor of ammonia was evident. From the hydrochlorides a benzene-sulfonamide derivative was prepared. Its melting point (uncorrected) was found to be 155° C. and showed no depression when mixed with the sulfonamide prepared from ammonia. It was analyzed for nitrogen and sulfur: found, N, 8.94; S, 20.8; calculated for $C_6H_5SO_2NH_2$, N, 8.91; S, 20.4. The fraction of hydrochlorides was purified by redistillation of the amines from 1 *N* NaOH into redistilled HCl and subsequent recovery of the hydrochloride salts. The dry residue was analyzed for nitrogen; found, 26.21%; calculated for NH_4Cl, 26.18%.

RESULTS AND DISCUSSION

Establishment of presence of volatile flavor in the distillate. A major part of the experimental approach to this study was based on the assumption that volatile flavor appears in the distillate of chicken broth. Before proceeding with the investigation it was therefore desirable to determine whether such distillates contain detectable flavor. To do this, a portion of broth was concentrated in the vacuum stripper as described in the experimental section. Half of the concentrated broth was reconstituted with distilled water, the other half with the condensate. Organoleptic evaluation of these two treatments (Table 1) showed that the portion of

TABLE 1
Flavor in chicken broth distillate

Medium used to reconstitute chicken broth concentrate	Times ranked first for intensity of chicken[1]	
	Flavor	Odor
Broth distillate	40	31
Water	8	17

[1] Difference for flavor is significant at the 1% level; for odor at the 5% level.

concentrated broth reconstituted with condensate ranked significantly higher than the other treatment for both flavor and odor. Thus these results establish presence of flavoring components in chicken broth distillate confirming the results of Bouthilet *(3)* and justifying examination of it for volatile flavoring components.

Chemical nature of volatile nitrogen. Both the amount and a clue to the nature of the volatile nitrogen containing compounds was determined by comparing nitrogen values of broth distillate before and after passage through sulfonated polystyrene cation exchange resin. In a typical case, the distillate, before fractionation, showed a pH of 9.7, a nitrogen content of 37.1 mcg. per ml., and a reducing ability of 2.6 μeq. per ml. After ion exchange the pH was 4.4, nitrogen dropped to less than 0.1 mcg. per ml., and the reducing values remained about the same. Nitrogen containing components absorbed on the resin were eluted with hydrochloric acid and isolated as the hydrochlorides. Analysis of the hydrochloride fraction and from it preparation of the benzene-sulfonamide derivative of ammonia showed that the hydrochloride fraction consisted of pure ammonium chloride. Therefore, with the possible exception of trace substances, ammonia accounts for all of the volatile nitrogen. This confirms the results of Bouthilet *(4)*.

Relation of volatile nitrogen to flavor. After chemical characterization of the volatile nitrogen, there remained the task of obtaining data which would show whether it is an important part of volatile flavor. This was readily accomplished by organoleptic comparison of the flavor of chicken broth concentrate reconstituted with the unfractionated distillate (nitrogen containing) and the flavor of concentrate reconstituted with nitrogen-free distillate. The feasibility of obtaining the latter has already been shown in the work described above. Results (Table 2) show that the portion reconstituted with nitrogen-free distillate ranked significantly higher. This shows not only the unimportance of volatile

TABLE 2
Flavor of decationized (nitrogen-free) chicken broth distillate

Medium used to reconstitute chicken broth concentrate	Times ranked first for intensity of chicken[1]	
	Flavor	Odor
Decationized broth distillate	26	26
Unfractionated broth distillate	18	17

[1] Differences are significant at the 5% level.

nitrogen to flavor but also that the volatile flavor is associated with either the neutral or acidic fractions of the distillate.

Chemical nature of volatile sulfur. Bouthilet *(4)* obtained results suggesting the presence, in distillate of chicken broth, of a sulfur-containing organic compound of importance to chicken flavor. Therefore it was of particular importance in the present study to completely characterize the volatile sulfur. Sulfur content of chicken broth distillate was first investigated. As described in the experimental section, the methylene blue method, which is specific for sulfide sulfur, was used for determination of sulfide sulfur in the distillate. It was found that typical concentrations of H_2S in broth distillates studied ranged from about 0.5 to 3 mcg. per ml. Total sulfur in the distillate was determined as barium sulfate following oxidation with alkaline permanganate. With the two quantitative methods available it was possible to determine what percent of the total sulfur in the distillate could be accounted for as hydrogen sulfide. However, before this could be done, two properties of the distillate were discovered, which if not recognized, could have led to an erroneous interpretation of results. One was the discovery that sulfide present in broth distillate was subject to oxidative loss. In order to account for the maximum possible sulfide sulfur it was therefore necessary to carry out analyses without delay to avoid significant oxidative loss. Another was the discovery that the concentration of sulfide sulfur varied from fraction to fraction of the distillate. This is illustrated in Figure 1. Hence, in carrying out this type of investigation it was necessary to collect the distillate in bulk to insure homogeneity before withdrawing aliquots for analysis. Analysis of the distillate of chicken broth for total and sulfide sulfur gave the results shown in Table 3. It is evident from these data that all sulfur present in the freshly prepared distillate consists of hydrogen sulfide. The constant amount of total sulfur over a period of time together with decreasing values of sulfide sulfur show that the latter undergoes chemical change, doubtless due to oxidation, to nonsulfide forms. Similar results were obtained in a model system of distilled water, H_2S and NH_3.

Volatile sulfur evolved during cooking of chicken in water was also studied. Chicken was cooked under reflux while a stream of nitrogen was passed through the cooking flask and subsequently through a system of traps. In the first experiment a determination was made of the percentage of the volatile sulfur fixed by 2% zinc acetate solution. A trap of hot alkaline permanganate was placed after the zinc trap to retain and oxidize to barium sulfate any sulfur which might pass the zinc acetate trap. At the end of the experiment, contents of the traps were analyzed for sulfur. In a typical experiment, 1.7 kg. of chicken cooked for 4 hours, yielded 15 mg. of sulfur in the zinc acetate trap but no sulfur could be detected in the alkaline permanganate trap. Hence the zinc acetate quantitatively absorbed the volatile sulfur. Since it has been shown by Sands *et al. (13)* that a 2% zinc acetate solution will quantitatively absorb H_2S and that mercaptans will be absorbed to some extent, it follows that the volatile sulfur consists of either H_2S and/or the mercaptan type. The next experiment, described below, was carried out to determine whether any mercaptan sulfur was present.

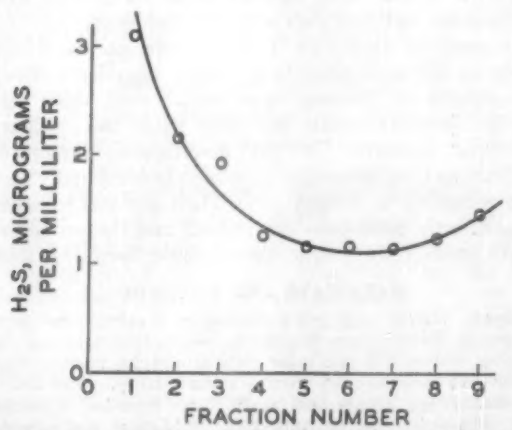


Figure 1. Distribution of H_2S in fractions of chicken broth distillate.

TABLE 3
Total sulfur and sulfide sulfur content of chicken broth distillate

Time after distillation, hours	Sulfide sulfur	Total sulfur
	mcg./ml.	*mcg./ml.*
0	1.91	1.90
23	1.15	2.02
47	0.43	1.89

Shaw *(14)* has shown that a trap of cadmium chloride and sodium carbonate will quantitatively absorb H_2S and mercaptans. Furthermore, he has shown that cadmium mercaptides may be quantitatively separated from cadmium sulfide. Volatile products from 1.3 kg. of chicken during a 4.5-hour cooking period were swept with nitrogen gas into a cadmium chloride-sodium carbonate trap and the cadmium precipitate was separated into sulfide and mercaptan fractions as described by Shaw *(14)*. Analysis of the two fractions for total sulfur showed that 15.4 mg. of sulfur were present in the sulfide fraction while only 0.08 mg. of sulfur was found in the mercaptan fraction. The trace found as mercaptan sulfur is considered insignificant since experimental error could account for it.

Relation of sulfide to flavor. Liberation of sulfide during cooking has been observed for a wide variety of foods and is gaining recognition as a volatile flavoring component, particularly of cooked and heated proteinaceous foods. Sulfide has been identified by Almy *(1)* among the volatile components of canned fish, by Crocker *(6)* as a flavoring substance of cooked beef, has been associated with the cooked flavor of milk by Gould and Sommer *(9)*, and is considered to be one of the principal flavoring substances of cooked eggs *(10)*. Bouthilet *(4)* concluded that flavor of chicken is associated with the volatile sulfur fraction which has been shown by the present study to occur predominantly or entirely as sulfide. However, on the basis of its occurrence among the volatile constituents of various cooked meats, it would seem that sulfide is a general contributor to most if not all cooked meat flavors and that obviously additional factors and substances are involved in making up the composite volatile mixture which is recognized as characteristic of chicken flavor.

SUMMARY

Distillate of chicken broth was studied to determine whether it contained detectable flavor and particularly to characterize the nitrogen and sulfur and determine how these are related to flavor. Comparison of flavor in chicken broth concentrate reconstituted with distilled water with that reconstituted with broth distillate showed that the latter contained detectable chicken flavor. Volatile nitrogen present in chicken broth distillates studied was found to consist entirely of ammonia. Taste-panel evaluation of broth concentrate reconstituted with unfractionated (nitrogen-containing) and nitrogen-free broth distillate showed that the latter had most intense flavor, thus demonstrating that volatile nitrogen does not constitute part of characteristic chicken flavor, but indicates, on the contrary, that volatile flavor is associated with the neutral or acidic components.

Sulfur present in freshly prepared broth distillate was found to consist entirely of hydrogen sulfide as shown by the agreement between its total and sulfide sulfur content. At room temperature, sulfide sulfur in the distillate oxidized rapidly (79% in 48 hours) to non-sulfide form. It was found that volatile sulfur evolved when chicken was cooked in water was quantitatively absorbed by 2% zinc acetate solution, thus limiting volatile sulfur to either the sulfide or mercaptan type. Absence of mercaptan sulfur was shown when determination of the sulfide and mercaptan sulfur content of the cadmium precipitate revealed that, within limits of experimental error, all sulfur was present in the sulfide form. It is concluded that sulfide is a contributor to meat flavors in general but that obviously additional factors and substances are involved in making up the composite mixture recognized as chicken flavor.

Acknowledgments

It is a pleasure to acknowledge the assistance of the following personnel of the Western Utilization Research Branch: L. M. White and G. E. Secor for microkjeldahl nitrogen determinations and A. A. Campbell and L. Fletcher for help in organoleptic evaluations.

LITERATURE CITED

1. Almy, L. H. A method for the estimation of hydrogen sulfide in proteinaceous food products. *J. Am. Chem. Soc.*, **47**, 1381 (1925).
2. Bouthilet, R. J. A note on the nature of a flavor constituent from poultry meat. *Food Technol.*, **3**, 118 (1949).
3. Bouthilet, R. J. Chicken flavor: Separation and concentration of its volatile components from broth. *Food Research*, **15**, 322 (1950).
4. Bouthilet, R. J. Chicken flavor: The fractionation of the volatile constituents. *Food Research*, **16**, 137 (1951).
5. Bouthilet, R. J. Chicken flavor: The source of the meat flavor component. *Food Research*, **16**, 201 (1951).
6. Crocker, E. C. Flavor of meat. *Food Research*, **13**, 179 (1948).
7. Dimick, K. P., and Makower, B. A laboratory-scale continuous vacuum flash evaporator. *Food Technol.*, **5**, 517 (1951).
8. Friedmann, T. E., and Klaas, R. The determination of ethyl alcohol. *J. Biol. Chem.*, **115**, 47 (1936).
9. Gould, I. A., and Sommer, H. H. Effect of heat on milk with special reference to the cooked flavor. Michigan Agr. Expt. Station, *Technical Bull. 164* (1939).
10. Lowe, Belle. *Experimental Cookery*, 4th ed., 1955, John Wiley and Sons, Inc., New York, p. 343.
11. Pippen, E. L., Campbell, A. A., and Streeter, I. V. Flavor studies. Origin of chicken flavor. *J. Agr. Food Chem.*, **2**, 364 (1954).
12. Potter, E. F., and Jones, C. B. Separation and determination of protein sulfur, sulfide sulfur and other sulfur in sodium sulfide dispersions. *Ind. Eng. Chem., Anal. Ed.*, **15**, 15 (1943).
13. Sands, A. E., Grafius, M. A., Wainwright, H. W., and Wilson, M. W. The determination of low concentrations of hydrogen sulphide in gas by the methylene blue method. Report of investigations 4547, Bureau of Mines, U. S. Dept. Interior (1949).
14. Shaw, J. A. Rapid determination of hydrogen sulfide and mercaptan sulfur in gases and in aqueous solutions. *Ind. Eng. Chem., Anal. Ed.*, **12**, 668 (1940).
15. Snedecor, G. W. *Statistical Methods*, 4th ed., 1946, Iowa State College Press, Ames, Iowa.

Bacterial Spoilage of Shell Eggs. IV. Identification of Spoilage Organisms

M. L. E. Florian and P. C. Trussell
Division of Applied Biology, British Columbia Research Council, Vancouver 8, Canada

(Manuscript received August 31, 1956)

Previous work by Trussell *et al. (14)* has shown that the incidence of spoilage bacteria in nest-clean eggs from commercial producers is extremely low. Instances of congenital contamination are rare and Stuart and McNally *(11)* maintain that the shell is sterile when the egg is laid. The egg is infected subsequently to laying, therefore, through contact with nest materials, broken and spoiled eggs, dirt and faecal material.

The numerous studies on the bacterial spoilage of shell eggs have been adequately reviewed by Romanoff and Romanoff *(9)* and Tanner *(12)*.

Some attempts have been made to correlate the macroscopic changes associated with egg rot to a specific causative organism. *Pseudomonas, Proteus, Escherichia, Alcaligenes* and *Aerobacter* spp. have been found in black-rot eggs *(4, 6, 15)*. Red and green rots have been associated with strains of *Pseudomonas*, while a *Proteus* has been isolated from a custard-like egg rot *(4)*. In Australia the common colorless rot has been linked with *Achromobacter*, red rots with *Serratia* sp. and pink rots with a *Pseudomonas sp. (1)*.

In previous studies *(1, 4, 7)*, no attempts have been made to differentiate between those organisms which are capable of infecting eggs directly and those secondary invaders which can only follow the primary infectious bacteria. In this investigation organisms originating from local eggs have been isolated and classified according to Bergey *(2)*. Their abilities to infect eggs directly have been determined and the properties of rot produced by specific bacteria have been described.

MATERIALS AND METHODS

Eggs. Infected eggs were obtained in 4 groups; two were secured at different time intervals as rejects from a commercial grading station and the other two groups by holding eggs, which had been received from a commercial producer and a commercial egg storage firm, at 25° C. for 6 weeks. A "Vogelite" ultra-violet candling lamp, Model 301A, was used to select the eggs with visible abnormalities (cloudiness, stuck yolks, blood- and meat-spots).

For the infectivity tests, nest-clean, infertile eggs, laid by White Leghorn hens, were secured from the poultry farm of the University of British Columbia.

Bacteriological media. The following media were used: (a) selective medium of Norris *et al. (8)* for pseudomonads, (b) medium of King *et al. (5)* for fluorescin production by pseudomonads, (c) tryptone broth, (d) litmus milk, (e) Koser-citrate broth, (f) methyl-red, Voges-Proskaueur broth, (g) Kligler iron agar, (h) Russell double sugar agar, (i) nutrient gelatine, (j) nitrate agar, (k) urea agar base and (l) bismuth sulfite agar. The preparation of media, (c) to (l) inclusive, used for physiological testing of bacteria, is described in the Difco manual *(3)*.

Aseptic removal of egg meats from the shell. Each egg was immersed for 2 minutes in 70% ethanol, aseptically removed from the alcohol, drained, placed in a deep Petri dish, ignited, and rolled till the flaming stopped. The egg was aseptically removed from the Petri dish, opened with a sterile knife and the contents dropped into a sterile wide-mouth 500 ml. Erlenmeyer flask. For sampling spoiled eggs containing gas, a small hole was drilled through the shell and a portion of the contents removed with a sterile hypodermic syringe.

Isolation of spoilage organisms. Serial dilutions of each egg meat were plated using both nutrient agar and the pseudomonad medium of Norris *et al. (8)*. After 72 hours incubation at 25° C. morphologically-different colonial types were picked from the plates and purified by the standard techniques of transplanting to broth and subsequently streaking on agar plates. This technique was repeated until purity of the cultures was assured.

Identification of isolates. The morphological and physiological characteristics of the individual isolates were determined according to the procedures in the *Manual of Methods for the Pure Culture Study of Bacteria (10)*. Subsequently, classification of each isolate according to Bergey *(2)* was attempted.

Inoculation of eggs with pure cultures. Newly-laid, nest-clean eggs were held for about 2 weeks at room temperature until a large air cell formed. Each egg was dipped in 70% ethanol and the blunt end swabbed with 2% lysol, before and after drilling through the shell with a high speed drill at the centre of the air sac. The outer membrane was pierced with the sharp tip of a sterile pipette and 0.1 ml. of an 18-hour, nutrient broth culture was delivered into the air cell. Following inoculation the hole was sealed with sterile paraffin wax.

Each isolate was inoculated into an average of 4 eggs (2 only for each *Pseudomonas fluorescens* isolate). Control eggs were inoculated with sterile nutrient broth. Eggs inoculated with *P. fluorescens* were incubated at 20° C., all other eggs at 25° C. The eggs were candled every 2 days for 30-40 days. The meats of those eggs showing decomposition were aseptically removed at the time of detection and streaked on nutrient agar. The eggs remaining at the end of the 30-40 day holding period were also checked for spoilage organisms by streaking on agar. In those few instances where the infecting and the isolated organism did not correspond, or where infectivity results were inconclusive, the procedure was repeated with new sets of eggs.

Macroscopic observations were made on the types of spoilage produced by different species of infectious bacteria.

RESULTS AND DISCUSSION

Isolation and classification of pure cultures. Number of eggs handled, number rejected by candling, and the number actually infected, together with the number of bacterial isolates obtained therefrom, are shown in Table 1. A total of 118 eggs were candling rejects; however, only 81 of these were found to contain bacteria. Of the 81 eggs containing bacteria, 33 were fluorescent under ultra-violet candling.

The 81 infected eggs yielded 228 cultures, but 31 perished before they could be classified. The morphological and physiological characteristics of the remaining 197 isolates are given in Table 2. As in most classification studies, absolute identification of all organisms encountered proved difficult and in some instances the bacterial characteristics did not exactly correspond with classical descriptions. However, the following species were identifiable according to Bergey *(2)* with reasonable exactitude:

TABLE 1
Source and numbers of spoiled eggs and bacterial isolates

Lot no.	Source	Total no. of eggs	No. of candling rejects	No. of infected eggs	No. of bacterial isolations
1	Commercial Rejects	23	23	17	38
2	Commercial Rejects	28	28	23	69
3	Commercial Storage	360	19	14	35
4	Commercial Producer[1]	180	48	27	86

[1] With a previous record for a high incidence of spoilage.

Alcaligenes bookeri (Ford) Bergey *et al.*
Alcaligenes faecalis Castellani and Chalmers
Alcaligenes recti (Ford) Bergey *et al.*
Alcaligenes metalcaligenes Castellani and Chalmers
Pseudomonas fluorescens Migula
Pseudomonas putrefaciens (Derby and Hammer) Long and Hammer
Proteus vulgaris Hauser
Proteus melanovogenes[a] Miles and Halnan
Flavobacterium invisible (Vaughan) Bergey *et al.*
Flavobacterium lactis Bergey *et al.*
Escherichia freundii (Brask) Yale
Escherichia intermedium (Werkman and Gillen) Vaughn and Levine
Paracolobactrum intermedium Borman, Stuart and Wheeler
Paracolobactrum aerogenoides Borman, Stuart and Wheeler
Achromobacter liquefaciens (Eisenberg) Bergey *et al.*
Aerobacter cloacae (Jordan) Bergey *et al.*

Two physiologically different strains, designated here as (a) and (b), were found for *A. bookeri, P. vulgaris* and *P. intermedium*.

In addition to the above, 5 isolates of *Flavobacterium*, 3 of coli-aerogenes, and 4 of *Achromobacteriaceae*, could not be identified as to species.

The above species should not be regarded as a complete listing of organisms which may be found in naturally-infected eggs. In addition to the 31 unidentified isolates that perished, many species present in relatively low numbers in the eggs may have been missed as the standard plating technique permits isolation of only the more dominant flora. Further, by studying infected eggs from a greater number of sources, a wide variety of species may have been found. On the other hand, it is interesting that only Gram-negative rods were found in these isolation studies.

Distribution of organisms according to source. The distribution of species between the 4 source lots of eggs is given in Table 3. Although no case histories of the 4 lots of eggs are available, distribution of bacterial species between the 4 groups is obviously different. The principal spoilage organism in Lot 1 and 3 was *P. fluorescens*, and in Lot 4, *Alcaligenes* spp. In Lot 2, *Pseudomonas, Proteus, Paracolobactrum* and *Escherichia* spp. were all of significance.

Since the dominant species of infecting bacteria found in all 4 lots of eggs are of intestinal origin, the species

[a] Classified from the description of Miles and Halnan *(7)*; Bergey *(2)* suggests this organism is not a *Proteus*.

infecting any one group of eggs is probably associated with the intestinal flora of the birds from which the eggs have come.

Differentiation of spoilage organisms according to infectability. In Table 4, 176 of the spoilage isolates are classified as to their ability, in pure culture, to penetrate the inner shell membrane and infect the shell contents. Those species which possess this ability are designated as primary invaders, and those which do not as secondary invaders. This secondary group probably enters the egg subsequent to or in conjunction with penetration of the inner membrane by a primary invader.

Considerable variation exists between the ability of members of the primary group to infect eggs. For example, nearly all the eggs inoculated with *P. fluorescens, A. bookeri* (a) and *Paracolobactrum intermedium* (a) showed rot within 30 days whereas those eggs inoculated with *P. vulgaris* (b) induced rot in only 14% of the eggs. Varying degrees of penetrability between these extremes were encountered. These primary invaders originate from various sources. The majority are intestinal bacteria, indicating fecal contamination. However, according to sources listed in Bergey *(2)*, infection by *P. putrefaciens* and *F. invisible* indicate probable infection from soil or water.

As indicated in Table 3, *Achromobacter liquefaciens, Alcaligenes bookeri* (b), coli-aerogenes indeterminate and *Paracolobactrum intermedium* (b) were found in pure culture in four of the original spoiled eggs, yet in subsequent tests they lacked the ability to penetrate egg membranes. In these cases the secondary invaders had probably outgrown the primary invaders so that the organisms responsible for breakdown of the membranes were not picked up by the plating methods.

By using candling as a means of gauging the amount of decomposition of egg contents, considerable variation was found in the rate of bacterial decomposition of eggs inoculated with different species. With *Proteus melanovogenes,* infection in 19 out of 24 inoculated eggs was discernible by candling after only 5 days incubation. The activity of *P. fluorescens* can be detected early by candling because of fluorescin production. A non-motile species, *Alcaligenes faecalis,* after 20 days incubation, showed detectable decomposition in only one of 20 inoculated eggs. A wide degree of variation in rates of infection between the above extremes was encountered.

The principal barrier to entry of egg interiors by bacteria is the impervious inner membrane. In studies to be reported separately *(16)*, it has been found that *P. fluorescens* is able to penetrate the inner membrane in approximately 20 hours. Membrane proteolysis is a

TABLE 2
Identification of bacterial isolates

Identification	No isolations	Fluorescence	Gram Stain	Morphology	Motility	Flagella	Glucose utilization	Lactose utilization	Methul-Red Test	Voges Proskauer Test	Urea Utilization	H_2S Formation	Citrate Utilization	Gelatine Liquefaction	Optimum Temperature	Nitrate reduction	Litmus Milk	Colonies on Bismuth Sulphite agar	Colony Chromogenesis
Alcaligees	72																		
bookeri (a)	52	–	–	Rods	+	Polar, Peri.	–	–	–	–		–	–	+		±	Base P		Cream
bookeri (b)	6	–	–	Rods	+	Polar, Peri.	–	–	–	–		–	–	+		–	Base Slow P		Cream
faecalis	5	–	–	Rods	+	Peri.	–	–	–	–		–	–	–		+	Base		Cream
recti	5	–	–	Rods	+		–	–	–	–		–		+		+	Base		Cream
metalcaligenes	4	–	–	Rods	–		–	–	–	–		–		–		–	Base		White
Pseudomonas	58																		
fluorescens	52	+	–	Rods	+	Polar	–	–	–	–		–	–	+	20° C.	±	Base P		Pink
putrefaciens	6	–	–	Rods	+	Polar	–	–	–	–		+	–	+		±	Rapid R		Rosy brown
Proteus	21																		
vulgaris (a)	9	–	–	Rods	+	Peri.	AG	–	+	–	+	+	–	+		+	NC⟶Acid	Small green	Pearl
vulgaris (b)	6	–	–	Rods	+	Peri.	A	–	+	–	+	+	+	+		+	Sl. Acid	Small green	Pearl
melanovogenes	6	–	–	Rods	+	Peri., Polar	A	–	+	–	–	–	–	+		+	Acid⟶P		Tan
Flavobacterium	10																		
invisible	4	–	–	Rods	+		–	–	–	–		–		–		–	NC		Cream
lactis	1	–	–	Rods	+		–	–	–	–		–	+	–		+	Acid		Yellow
indeterminate	5	–	–	Rods	+		–	–	–	–		–	+	–		+	NC Base		Yellow
Escherichia	10																		
freundii	8	–	–	Pleo. Rods	±	Peri.	AG	A	+	±	–	+	+	–		+	Acid		Grey
intermedium	2	–	–	Pleo. Rods	+		AG	A	+	–	–	–	–	–		+	Acid		Grey
Paracolobactrum	10																		
intermedium (a)	4	–	–	Pleo. Rods	+	Peri.	AG	–	+	–	–	–	+	±		+	Acid C		White
intermedium (b)	4	–	–	Rods	+		A	A±	+	–	–	–	–	–		–	NC		Cream
acrogenoides	2	–	–	Pleo. Rods	–		AG	–	–	+	±	±	+	–		+	Acid	Black metallic halo	White
Achromobacter	5																		
liquefaciens	5	–	–	Rods	+	Peri.	–	–	–	–		–		+		–	NC		Cream
Aerobacter	4																		
cloacae	4	–	–	Pleo. Rods	+	Peri.	AG	A	–	+	–	–	+	+		+	Acid C		White
Coli-Aerogenes indeterminate	3	–	–	Pleo. Rods	–	Peri.	AG	A	+	–	+	–	+	–		+	Acid	Small black	White
Achromobacteriaceae indeterminate	4																		
Died before identification	31																		
Total	228																		

+ = positive
– = negative
± = variable

Pleo = pleomorphic
Peri = peritrichous
A = acid

AG = acid and gas
P = proteolysis
R = reduction

NC = no change
C = coagulum
Sl = slight

TABLE 3
Number of eggs in different egg lots infected with identified species

Species	Lot 1 (17 eggs)	Lot 2 (23 eggs)	Lot 3 (14 eggs)	Lot 4 (27 eggs)	Total (81 eggs)
Pseudomonas					
fluorescens	16	7	13	4	40 (19)[1]
putrefaciens	3	1		1	5
Alcaligenes					
bookeri (a)	1	1		21	23 (7)
bookeri (b)	1			4	5 (1)
faecalis		1		4	5
recti	1	1		3	5
metalcaligenes		1		2	3
Proteus					
vulgaris (a)		5			5
vulgaris (b)		4			4 (1)
melanovogenes	1	4			5
Paracolobactrum					
intermedium (a)		3		1	4 (1)
intermedium (b)		3			3 (1)
aerogenoides		1		1	2
Flavobacterium					
invisible	1	1		1	3
lactis			1		1
indet.	2		1	2	5
Escherichia					
freundii		5			5
intermedium		2			2
Achromobacter					
liquefaciens		2		3	5 (1)
Aerobacter cloacae	2		2		4
Coli-aerogenes					
indet.		3			3 (1)
Achromobacteriaceae					
indet.		1	1	1	3

[1] Number of eggs containing only one species of organism.

probable explanation for this penetration and the difference between primary and secondary invaders may be due to the presence or absence in the bacteria of an enzyme system capable of lysing the inner membrane. Similarly the variation in rate of infection between individual species may indicate differences in the reaction rates of their membrane-lysing enzyme systems.

Association of type of egg-rot with causative organisms. In Table 4 are listed the types of rot associated with each primary invading species. The visual changes and odor for each type of rot are described in detail in Table 5. These changes are specific to and characteristic of the individual infecting bacterial species. Although the presence of mixed infections in spoiled eggs is the rule (Table 3), the color of the rot is a guide to the predominant infecting organism. A color photograph illustrating the various types of rots encountered was taken for record purposes.

Rots caused by *P. fluorescens* have been classified here as "fluorescent green" rather than "green" *(1, 4)* to avoid confusion with the "green" rot caused by *Alcaligenes* spp. In the latter rot, previously classified as "black" *(1, 4, 15)*, the yolk changes as spoilage progresses, from a soft mass streaked with olive green to a firm solid, varying in color from dark green at the air sac to black at the opposite end. In the "yellow" rot, also caused by A. *bookeri* (a), the yolk is solid, translucent, and dark yellow, occasionally streaked with olive green. In this study, "black" has been used to describe the rot caused by *P. melanovogenes*. This rot is readily distinguished from "green" rot by the complete absence of green color in the yolk and by the green color of the albumen compared to the orange-tinted albumen in "green" rots. The "red" rot described here is caused by *P. putrefaciens*, which has not been reported as an egg spoilage organism heretofore. Previously "red" rots have been ascribed to *P. fluorescens (4)* and *Serratia (1)*. The "custard" rot is caused by *P. vulgaris* (a) and *P. intermedium* (a) and derives its name from the custard-like color and texture of the yolk. Haines *(4)* has ascribed this type of rot to a *Proteus* species, but states that *Proteus* commonly causes black rot. The "colorless" rot caused by *A. metalcaligenes* and *A. faecalis* compares in its description to the rot ascribed by Alford *(1)* to *Achromobacter*.

SUMMARY

1. From 81 infected eggs obtained from four sources, 197 organisms were isolated in pure culture. All organisms were Gram-negative, rod-shaped bacteria mainly of intestinal origin.

2. The principal spoilage species were *Pseudomonas fluorescens* and *Alcaligenes bookeri* strain (a) which were found in about 50% and 25%, respectively, of the infected eggs examined.

TABLE 4
Differentiation of spoilage organisms according to their ability to penetrate and infect shell eggs

Species	Isolates tested	Eggs inoculated	No. of eggs candled bad in				Infected %	Type of rot
			5 days	10 days	20 days	30 days		
Primary Invaders								
Pseudomonas fluorescens	52	104	58	93	104	104	100	Fluorescent
Alcaligenes bookeri (a)	41	161	39	110	129	159	100	Green and yellow
Paracolobactrum intermedium (a)	4	14	1	7	14	14	100	Custard
Proteus melanovogenes	6	24	19	20	21	21	87	Black
Pseudomonas putrefaciens	6	24	6	11	19	20	84	Red
Proteus vulgaris (a)	9	34	0	9	23	28	83	Custard
Alcaligenes metalcaligenes	4	16	0	0	1	6	38	Colourless
Flavobacterium invisible	4	16	0	2	3	5	31	Mixed
Alcaligenes faecalis	5	20	0	0	1	6	30	Colourless
Proteus vulgaris (b)	6	24	0	0	1	4	14	Homogeneous, rusty red
Secondary Invaders								
Achromobacteriaceae indeterminate	3	12				0		
Achromobacter liquefaciens	5	18				0		
Aerobacter cloacae	3	12				0		
Alcaligenes bookeri (b)	3	12				0		
Alcaligenes recti	5	14				0		
Coli-aerogenes indeterminate	3	12				0		
Escherichia freundii	4	16				0		
Escherichia intermedium	1	4				0		
Flavobacterium indeterminate	5	16				0		
Flavobacterium lactis	1	4				0		
Paracolobactrum aerogenoides	2	4				0		
Paracolobactrum intermedium (b)	4	16				0		

TABLE 5
Changes in eggs associated with spoilage by different bacterial species

Days after inoculation	Changes			Odour
	Albumen	Yolk	Membranes	
		Fluorescent—Green—P. fluorescens		
3	Fluorescent on candling	None	None	None
10	Chartreuse green in white light Fluorescent in black light	Stuck	None	None
30	Thin; light tan colour; losing fluorescence	Encrusted at air sac end in pink bacterial mass	None	None
60	Thin; tea coloured; no fluorescence	Completely encrusted in bacterial mass, vitelline membrane disintegrating	None	Cheesy
		Red—P. putrefaciens		
30	Thin; light blood-red to rusty orange	Soft, mealy; olive-green streaks; stuck	Rusty-orange mass on air sac membrane	Ammonia, tarry, putrid
90	Thin; light blood-red	Soft; black	Greyed; orange brown	Strong ammonia tarry, putrid
		Green—A. bookeri (a)		
20	Thin; orange brown; transparent	Vitelline membrane streaked with olive green; gelatinous	None	Hazel nut
30	Thin; orange brown; transparent	Opaque gelatinous solid olive green to black	Weak	Hazel nut
		Yellow—A. bookeri (a)		
20	Thin; orange brown; transparent	Mealy; dark yellow, translucent	None	Hazel nut
30	Thin; orange brown; transparent	Gelatinous solid; translucent dark yellow	Weak	Hazel nut
		Custard—P. vulgaris (a), P. intermedium (a)		
20	Translucent	Stuck; vitelline membrane weak	None	Slight putrid
30	Thin; orange tint	Opaque-custard appearance outside — swollen; inside—normal	None	Slight putrid
60	Thin; orange tint	Solid opaque custard yellow	None	Putrid
		Black—P. melanovogenes		
20	Thin; creamy grey-green with creamy bacterial masses	Gelatinous solid; opaque black	Weak, grey	Strong H S
		Colourless—A. faecalis, A. metacaligenes		
30	Normal	Air-sac end encrusted in creamy bacterial mass; vitelline membrane weak	None	None

3. The distribution of bacterial species in infested eggs varied between different egg sources. Of the 81 eggs, 32 contained pure cultures of one organism.

4. Of 19 identified species and 11 unclassifiable isolates found in eggs, only 10 identified species in pure culture were capable of penetrating the inner membrane of the egg and infecting the egg contents. These were: *Pseudomonas fluorescens, P. putrefaciens, Alcaligenes bookeri* strain (a), *A. metalcaligenes, A. faecalis, Proteus vulgaris* strains (a) and (b), *P. melanovogenes, Flavobacterium invisible* and *Paracolobactrum intermedium* strain (a).

5. Species that were found growing in eggs but which were incapable of penetrating egg membranes were: *Achromobacter liquefaciens, Aerobacter cloacae, Alcaligenes bookeri* strain (b), *A. recti, Escherchia freundii, E. intermedium, Flavobacterium lactis, Paracolobactrum aerogenoides* and *P. intermedium* strain (b). Three unclassifiable *Achromobacteriaceae,* three coli-aerogenes and five *Flavobacterium* also were unable to penetrate egg membrane.

6. The rate of egg-membrane penetration and the rate of egg-meat deterioration varied with different bacterial species.

7. The odor and appearance of eggs spoiled by specific bacterial species are described.

LITERATURE CITED

1. Alford, L. R., Holmes, N. E., Scott, W. J., and Vickery, J. R. Studies on the preservation of shell eggs. I. The nature of wastage in Australian export eggs. *Aust. J. App. Sci.*, **1**, 208-214 (1950).
2. Breed, R. S., Murray, E. G. D., and Hitchens, A. P. *Bergey's Manual of Determinative Bacteriology.* 1948, 6th Ed., The Williams and Wilkins Co., Baltimore, Md.
3. Difco Manual of Dehydrated Cultures Media and Reagents for Microbiological and Clinical Laboratory Procedures. 1953, 9th Ed., Difco Laboratories, Detroit 1, Mich.
4. Haines, R. B. Observations on the bacterial flora of the hen's egg with a description of new species of *Proteus* and *Pseudomonas* causing rots in eggs. *J. Hyg.*, **38**, 338-355 (1938).
5. King, J. V., Campbell, J. J. R., and Eagles, B. A. The mineral requirements for fluorescin production. *Can. J. Research,* **26C**, 514-519 (1948).
6. Miles, A. A., and Halman, E. T. A new species of micro-organism *(Proteus melanovogenes)* causing black rot in eggs. *J. Hyg.*, **37**, 79-97 (1937).
7. Miller, W. A., and Crawford, L. B. Some factors influencing bacterial penetration of eggs. *Poultry Sci.*, **32**, 303-309 (1953).
8. Norris, F. C., Campbell, J. J. R., and Ney, P. W. The intermediate metabolism of *Pseudomonas aeruginosa. Can. J. Research,* **27C**, 157-164 (1949).
9. Romanoff, A. L., and Romanoff, A. J. *The Avian Egg.* 1949, John Wiley and Sons, Inc., New York, N. Y.
10. Society of American Bacteriologists. *Manual of Methods for the Pure Culture Study of Bacteria.* 1955, Biotech Publications, Geneva, N. Y.
11. Stuart, L. S., and McNally, E. H. Bacteriological studies on the egg shell. *U. S. Egg Poultry Mag.*, **49**, 28-31 (1943).
12. Tanner, F. W. *Microbiology of Foods.* 1944, Garrard Press, Champaign, Ill.
13. Trussell, P. C. Bacterial spoilage of shell eggs. I. Bacteriology. *Food Technol.*, **9**, 126-129 (1955).
14. Trussell, P. C., Triggs, R. E., and Greer, B. A. Bacterial spoilage of shell eggs. III. Farm practices promoting spoilage. *Food Technol.*, **9**, 134-137 (1955).
15. Winter, A. R. Black rot in fresh shell eggs. *U. S. Egg Poultry Magazine,* **48**, 506-509 (1942).
16. Walden, C. C., Allen, I. V. F., and Trussell, P. C. The role of the egg shell and shell membranes in restraining the entry of micro-organisms. *Poultry Sci.*, (in press).

(Continued from page 22 preceding technical papers)

utilized for cals. and can decrease N and K deficits induced by diets inadequate in caloric content.

Metabolism of trichloroethylene in the bovine.

SETOK, T. A., AND SCHULTZE, M. O. (Univ. Minnesota, St. Paul). *Proc. Soc. Exptl. Biol. Med., 90* (2), 314-16 (1955); *Biol. Abstr., 30* (7), No. 18889 (1956).

From 3 to 12 g. of trichloroethylene was given orally to calves, weighing about 100 lbs., for 4 to 5 days. Analysis of the urine by a modification of the Fujiwara reaction showed about 1% of the trichloroethylene was excreted as trichloroacetic acid and from 13 to 25% as trichloroethanol (free trichloroethanol and/or conjugated as urochloralic acid). Excretion of trichloroethanol ceased quickly after feeding of trichloroethylene was stopped, but excretion of tricholoroacetic acid, at reduced levels continued longer. Only traces of trichloroethylene were excreted in the urine.

ENGINEERING AND PLANT EQUIPMENT

A study of the application of the spouted bed technique to wheat drying.

MATHUR, K. B., AND GISHLER, P. E. (Natl. Research Council, Ottawa, Canada). *J. Appl. Chem., 5,* 624-36 (1955).

A spouted bed can be used to agitate solids that are of too coarse and uniform a particle size to be fluidized satisfactorily. Data are given for the application of this technique to the drying of wheat.

Safety factors—How far do you go in designing them into the plant?

DE LUCA, J. A. *Ind. Eng. Chem., 48* (7), 36-9A (1956).

Outline of methods used by Du Pont Company's Design Division to insure the incorporation of safety factors in a plant right from the design stage.

Flammable liquids in the laboratory.

MACCUTCHEON, S. M. (Dow Chem. Co.). *Ind. Eng. Chem., 48* (8), 63A (1956).

This editorial feature on safety sets up guides for the handling and storage of flammable liquids used in lab. quantities. To cope with the hazards of a wide variety and shifting quantities of solvents, proper storage and adequate restrictions and standards to ensure safe handling are recommended.

FOOD AND FOOD TECHNOLOGY

COCOA AND COCOA PRODUCTS

Determination of the shell content of cocoa products.

SACHSSE, M., AND GEUTING, M. (Chem. Landesuntersuchungsamt, Nordrhein-Westfalen, Ger.). *Zucker- u. Susswarenwirtsch., 9,* 453-5 (1956); *Chem. Abst., 50,* 12342c (1956).

Chem. methods alone are in general inadequate for detg. the extent of shell contamination of cocoa products. A combination of complete analysis and microscopic estn. of the mucoid cells and sclerides is more satisfactory.

COFFEE AND COFFEE PRODUCTS

The effect of coffee on gastric secretion.

PERSIDSKII, V. YA. (O. O. Bogomolets Med. Inst., Kiev). *Fiziol. Zhur., Akad. Nouk Ukr. R.S.R., 1,* No. 6, 76-82 (Russian summary 83) (1955); *Chem. Abstr., 50,* 10269e (1956).

A total of 161 exptl. observations were made on 39 individuals in normal health as controls. The exptl. group consisted of individuals who suffered certain gastrointestinal disturbances. Coffee was found to be a strong stimulant to gastric secretion in men under all conditions of the gastrointestinal tract. Under exptl. conditions a drink contg. 15-20 g. of coffee per 300 ml. of H_2O exerted the highest gastro-secretory stimulation, which was considered equivalent to that of beef bouillon. The stimulating gastro-secretory effect of coffee is conditioned basically by the neuro-humoral mechanism. The stimulating gastro-secretory effect of caffeine-free coffee is only slightly inferior to that of the original infusions of coffee. Raw and roasted coffee beans possess gastro-secretory effects of equal intensity. The addn. of sugar lowers the effect of the coffee, while the addn. of cream renders the stimulating effect of coffee upon the gastro-secretion to become latent; it also lowers the HCl content of the stomach and delays the emptying of the stomach into the intestine. It is suggested that black coffee be excluded from the diet of patients with an hyperfunctioning gastric-secretion, or those suffering from gastric hyperacidity and especially from patients having gastric ulcers and hyperacidic gastritis. Such patients may be permitted to have coffee with cream and sugar. Patients with a lowered gastro-secretory function should be given slightly sweetened coffee.

Niacin in coffee and its nutritional importance.

DAUM, M. G. *Arch. venezol. Nutr., 6,* 61-70 (1955); *J. Sci. Food Agr., 7* (8), ii-67 (1956).

Coffee, roasted, milled and hydrolyzed with HCl in an autoclave at 28 lb. pressure for 30 min., was assayed for niacin microbiologically using *Lactobacillus arabinosus,* and was found to contain 33.9 mg. per 100 g. Coffee prepd. as a 10 g. per 100 cc. infusion by household methods gave 3.4 mg. per 100 cc.

FATS AND OILS

Oil distribution in different parts of the coconut kernel.

SETHI, A. S., AND KARTHA, A. R. S. (Indian Agricultural Research Inst., New Delhi, India). *Fats, Oils Det., 13* (5), B1: 310; 365 (1956).

There was no large variation between the characteristics of the oil from the innermost to the outermost layers as indicated by I values. From the variations in oil content it was postulated that the oil content in different parts of the kernel increases with the time for which the part has been growing on the basis of the development of the kernel to maturity. In sampling copra it is suggested that the upper and lower halves of the kernels should be selected in equal nos. and vertical sections of these should be collected for analysis.

MEAT AND FISH

Fish proteins and their utilization.

J. Sci. and Ind. Research (India) 14A (9), 453 (1955); *World Fisheries Abstr., 7* (4), 45-6 (1956).

The Dept. of Biochem., Inst. of Sci., Bombay, India, has been exptg. for the last 4 years on the prepn. and utilization of proteins from fish, particularly from the waste muscle of shark, skate, ray, fish meal, etc. Considerable progress has been made in the prepn. of edible proteins devoid of fishy smell. The fish proteins are easily digestible and contain all the essential amino acids in a fairly good proportion. The fish proteins have been prepd. by a simple method similar to that described for the manuf. of Wiking Eiweiss—a German fish protein product. *In vitro* digestion with proteolytic enzymes and microbiological assay of the protein hydrolyzates for amino acids revealed that the fish proteins compare favorably with casein. The high concns. of lysine, arginine, cystine and other amino acids in fish proteins make it a valuable supplement to diets composed mainly of cereals, pulses and vegetables. The fish proteins may find application in various industries like textiles, leather, dyes, confectionery, plastics, synthetic resins, and pharmaceuticals.

POTATOES

Flavor of dehydrated potatoes made from material treated with tetrachloronitrobenzene (TCNB).

GOODING, E. G. B., TUCKER, C. G., AND HARRIES, J. M. Fisheries and Food Research Establishment, Aberdeen, Scotland). *J. Sci. Food Agr., 7,* 411-16 (1956).

Tests conducted by panels in Aberdeen and London showed that King Edward potatoes treated with technical grade TCNB, yielded dehydrated products with a persistent taint, which increased with the period of storage of the raw potatoes. Heavy leaching during processing slightly reduced the extent of the taint.

PHYSICAL RESEARCH

A light scattering investigation of the retrogradation of amylose.

FOSTER, J. F., AND STERMAN, M. D. (Purdue Univ., Lafayette, Ind.). *J. Polymer Sci., 21,* 91-101 (1956).

Studies of the rate of retrogradation (pptn.) of amylose from aq. soln. utilizing turbidity studies, are reported. A marked dependence of rate on the prior phys. state of the amylose prepn. is demonstrated. In particular it is concluded that retro-

gradation is retarded by increased perfection of the helical cryst. form. It is suggested that the rate of retrogradation is primarily governed by the rate of disruption of the intramolecularly H-bonded helical form of amylose. The process of retrogradation is thus akin to the prevalent picture of protein denaturation.

RADIOCHEMICAL TECHNOLOGY

Longevity and causes of death from irradiation in physicians.

WARREN, S. (New England Deaconess Hosp., Boston, Mass.). *J. Am. Med. Assoc., 162,* 464-8 (1956).

This study indicates that not only do radiologists and specialists exposed to some degree of radiation show a shorter mean life span than that of physicians, assumed not to be exposed to radiation, but they die younger from practically every cause of death. This strongly suggests that radiologists are subject to some common factor that lowers their resistance to disease and hastens the aging process.

MISCELLANEOUS INFORMATION

New problems of food safety.

VORHES, F. A., AND LEHMAN, A. J. (Food and Drug Administration). *Public Health Repts., 71,* 571-6 (1956).

This article reviews the safety problems involved in food production, including a discussion of cold sterilization, changes in nutrient values as a result of radiation and the position of the Food and Drug Administration on the use of antibiotics and pesticides in foods. The author stresses that the main reason for concern is the uncertainty surrounding these substances and their effects rather than any knowledge of actual harm.

Progress in soybean research.

MCKINNEY, L. L. (U.S.D.A., Peoria, Ill.). *Soybean Digest, 16* (11), 66-72 (1956).

This report on research work on both soybean meal and oil by Northern Utilization Research Branch includes the development of methods for measuring urease in toasted and raw soybean oil meals, the use of the hemagglutinating test to correlate the degree of toasting with the nutritive value of soybean oil meals, the development of a flash desolventizer for producing undenatured soybean meal products for industrial applications, and the development of vinyl ether derivs. of soybean oil fatty alcs. for use in protective coatings.

PATENTS

Production of fish product.

HAMPTON, W. F., AND MAHER, E. J. Can. 530,243, September 11, 1956.

A process for making a fish product which comprises combining pieces of fish and freezing the combined pieces to form a substantially solid, integral mass, subdividing the frozen mass into consumer-sized units substantially all of which are formed of a plurality of fragments, coating the frozen units with a batter and subjecting the coated frozen units to deep fat frying, the batter being cooked to form a substantially continuous surface layer preventing disintegration of the units as they thaw throughout during cooking, and then refreezing the cooked units for storage and distribution to the consumer.

Cloud stabilization of citrus juice products.

STEVENS, J. W., AND PRITCHETT, D. E. Assignors to Sunkist Growers. U. S. 2,764,486, September 25, 1956.

A method of prolonging the natural cloud stability of a citrus beverage base contg. at least about 40% sol. solids inclusive of about 10% fruit acids which comprises incorporating therein an amt. of Na hexametaphosphate calcd. to provide about 20 to 400 p.p.m. thereof in the final beverage, and of locust bean gum to provide about 1 to 30 p.p.m. in the beverage.

Process for making fat-soluble vitamin active powder.

CANNALONGA, M. A., AND MAGID, L. Assignor to Hoffmann-La Roche Inc. U. S. 2,756,177, July 24, 1956.

A process which includes a step (1) of forming an aq. emulsion contg. dispersed therein a fat-soluble vitamin-active material and a protective colloid, and a step (2) of converting the emulsion to a dry particulate form contg. the non-aq. constituents of the emulsion: the improvement which comprises effecting the step (2) by introducing droplets of the emulsion into a mass of starchy powder predried to a moisture content of not more than about 8%, keeping the droplets in the powder sepd. from each other until a particulate form has been established in the individual droplets by loss of a portion of their contained H_2O to the starchy powder, and then completing the drying of the individual partially dry vitamin-active particles so formed; the individual droplets of the emulsion contg. such amt. of non-aq. constituents that upon complete drying the vitamin-active particles formed from the respective droplets are substantially entirely in the range from about coarser than 150 mesh to about finer than 10 mesh; the grains of the starchy powder being substantially entirely finer than 150 mesh.

Stabilized vitamin preparations.

WAKELY, R. D. Assignor to Peter Hand Brewery Co. U. S. 2,758,924, August 14, 1956.

A stable vitamin A prepn. comprising the reaction product of (a) a material selected from the group consisting of vitamin A and derivs. of vitamin A and (b) a member of the group consisting of desoxycholic acid and apocholic acid.

Food supplements and process of preparing the same.

BASH, I. J., AND ROSS, C. Assignors to C. Ross. U. S. 2,764,485, September 25, 1956. The method of prepg. homogeneous integrated particles of table salt including a minor proportion of vitamins which will not sep. from the salt upon standing or shaking, which comprises dissolving table salt in H_2O to form a satd. soln., adding vitamins to the soln., the temp. of the soln. being insufficiently high to cause deterioration of the vitamins, spraying the combination of salt soln. and vitamins under pressure into a vessel in order to secure an intimate and homogeneous mixt., drying and grinding the resulting product.

Method of producing condiments.

YANICK, N. S. Assignor to Kraft Foods Co. U. S. 2,760,869, August 28, 1956.

The method of preserving the characteristic flavor of fruits after breaking down the phys. structure of the fruit, the fruit being of the type which derives its characteristic flavor through enzymatic action between an enzyme and a substrate naturally occurring in the fruit, the method comprising the steps of non-destructively inhibiting the reaction of the enzyme with the substrate by minimizing the contact between the enzyme and substrate during the breakdown of the phys. structure, and maintaining the enzyme with the substrate in a viable form.

Process for hard candy coating food particles.

MASSMANN, W. F., MICHAEL, E. W., AND VOLLINK, W. L. Can. 528,802, August 7, 1956.

A process for hard candy coating articles which comprises heating a molten candy contg. about 3.6-6.5% moisture to a temp. of about 320°-350° F. under pressure not less than the vapor pressure of the candy mix so that its moisture content remains in the liquid phase in intimate contact with the sugar and spraying the candy onto the articles to be coated, the moisture content of the candy being reduced at least to about 2.5% as a result of the spraying.

Thaw indicator.

ZOPF, G. W. Assignor to Monsanto Chem. Co. U. S. 2,762,711, September 11, 1956.

The combination with a packaged frozen product, a thaw indicator comprising a clay-aromatic amine color body subject to change in color on contact with liquid H_2O but having its color unaffected by contact with ice and accessible to liquid H_2O on the occurrence of thawing.

Method and apparatus for freezing solvents out of solutions.

SLATTERY, G. H. U. S. 2,764,488, September 25, 1956.

The process of concg. orange juice which comprises the steps of cooling orange juice to about +5° C., introducing into the orange juice near the bottom thereof a continuous stream of droplets of deodorized kerosene-free mineral oil having a temp. of about —20° C., and removing from near the top of the orange juice the ice-encrusted droplets thereby formed.

A penny is small, yet, very often, it can be a big factor in the success of a business. Many businessmen, in the process of trying to save a penny or two, here and there, sometimes end up by losing dollars. The trick is to save without sacrifice. And so it goes in food processing.

Many processors use top grade ingredients and the latest techniques—yet, when it comes to spices—the small but significant ingredient that gives the product its taste, its sales appeal—many do their skill an injustice. After all this care, they cut corners when it comes to spices.

Knickerbocker spices...cinnamon, mace, nutmeg, paprika, ginger...are selected *for* manufacturers. They make the difference between a product that is just "O.K."—and one which will bring increased sales. From its raw state to its final form, each variety is kept uniform in quality...consistent in strength and flavor. And because Knickerbocker spices are *real* spices...there's less loss of flavor...you'll find they are stronger...more aromatic...*you'll use less!*

Not only will your customers *taste* the difference—your cash register will *show* the difference. Price lists and detailed information are available on request.

KNICKERBOCKER MILLS CO.
601-621 West 26th Street New York 1, New York

1842

KNICKERBOCKER
SPICES

Since 1842 America's Leading Importers of Fine Spices

IFT ACTIONS AND REACTIONS

(Continued from page 18 preceding technical papers)

his bench. Two reasons for this come to mind: Studies have been shown that the food industry employs few non-technical employees to assist their technical men. This runs the cost up quickly. Another factor is the expense that food studies involve. Much of the work done must be quickly pilot planted. Every research director knows that this procedure is the most expensive form of research. It will be interesting to have the facts—to see how many men there are in the product development phase of the industry. The Institute survey should provide some interesting information on this point.

TABLE 3 [1]

Cost of research per professional technical person: 1951

Industry	All firms Median figures
Food and kindred products	$15,000
Leather	10,000
Motor vehicles and parts	29,000
Aircraft and parts	21,000
Other transportation equipment	23,000
All firms	14,000

[1] "Spending for Industrial Research, 1951-1952." Page 40. Table III-5.

Table 4, from the National Science Foundation report *(1)*, shows that of the 3,699 million dollars spent on research and development in 1955, 54.2 million or 1.5% of the total appropriated by all industries was spent by the food industry. The transportation industry ranked lowest with 0.6% of the total.

Table 5, from the National Science Foundation Report *(1)* tells us that of the scientists and engineers employed in industry 2.6% are employed in the food industry. This compares with 11.3% in the chemical industry—the high industry in this category as in others. Note that 39% of the employed chemists are in the chemical industry. Only 7.7% are in the food industry.

Table 6, from the Manpower Resources study made by the U. S. Dept. of Labor *(2)*, points up the fact that of the chemists employed in the food industry 39% are in research and development, 32.6% are in analysis and in testing. Note the salary effect. Comparison of analysis versus development will be discussed later in this paper.

Table 7 discloses the attitude and philosophy of management in the food industry toward things technical. This table, taken from the Department of Labor Study *(2)*, shows that of the total number of industry-employed chemists surveyed in 1951, 47,270, only 2,373 were in the huge food and kindred products industry. This compares well with the phenomenal low of 13 in the furniture industry. (One wonders how they were ever ferreted out.) There were 17,596 chemists in the chemical industry.

TABLE 4 [1]

Research and development cost

Industry	Research and development cost	
	Millions of dollars	Percent distribution
All industries	$3,699.4	100.0%
Food and kindred products	54.2	1.5%
Chemicals and allied products	361.1	9.8
Electrical equipment	778.3	21.0
Transportation and other public utilities	20.4	0.6

[1] "Science and Engineering in American Industry." Page 14. Table 1.

TABLE 7 [1]

Industries in which chemists were employed, 1951

	Total
All industries	47,270
Food and kindred products	2,373
Furniture and fixtures	13
Chemical and allied products	17,596

[1] "Manpower Resources in Chemistry and Chemical Engineering." Page 68. Table A-13.

In summarizing this section, then, we should admit that cold numbers show the food industry to be a sleeping giant. By far the largest of the industries, it has a long way to go to equal the research expenditures of some of the smaller industries. It could be added that this state of affairs also applies to profit on the food sales dollar. There are those who attempt to correlate food industry research expenditure with food industry profit. The usual answer to this suggestion is that the food industry is different, it deals directly with con-

(Continued on page 32)

TABLE 5 [1]

Total scientists and engineers, by occupational group and industry, January 1954

Industry	All groups	Engineers	Chemists	Physicists	Mathematicians	Life scientists
	Percent distribution					
Food and kindred products	2.6%	1.5%	7.7%	0.7%	2.8%	21.9%
Chemicals and allied products	11.3	6.4	39.0	8.5	6.1	44.6
Machinery	10.9	13.1	1.8	5.7	4.6	0.7
Electrical equipment	11.0	12.5	5.0	28.6	10.4	(1) [2]
Aircraft and parts	8.8	10.1	1.7	16.1	14.1	(1) [2]

[1] "Scince and Engineering in American Industry." Page 21. Table 7.
[2] (1) Less than 50 cases.

TABLE 6 [1]

Functions performed by chemists in each industry, 1951

	All functions	Percent of chemists in—				
	Number	Research and development	Management	Analysis and testing	Production	Technical sales and services
All industries	47,274	45.1	11.1	18.3	6.2	4.2
Food and kindred products	2,372	39.0	15.3	32.6	7.8	3.2

[1] "Manpower Resources in Chemistry and Chemical Engineering." Page 75. Table A-18.

BUILDING BETTER "BODY" . . . . . for foods and drugs

For years, makers of candies, flavors, cough syrups, lozenges, lotions and other food, drug and cosmetic preparations have used Glycerine to provide humectant, demulcent or solvent action. Recent research with new thickening agents indicates that these properties of Glycerine will soon be extended to a whole new range of food and drug preparations.

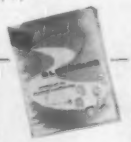
Glycerine has been known for years to be compatible with conventional water soluble gums and gelling agents such as Gum Arabic and Karaya. New studies show that Glycerine is also compatible with a majority of the new synthetic gums. In most cases, Glycerine supplements the bodying action of these gums, and the resultant formulations are relatively unaffected by freezing and thawing.

Other fields, too, will benefit from this compatibility of Glycerine. Nontoxic lubricants are now possible. Important improvements in printing inks, grinding and polishing pastes, gasket seals—all making use of Glycerine's unique balance of properties—are promised.

The versatility that has won such wide acceptance for Glycerine in the past continues to open new doors to chemical progress. In paints, foods, pharmaceuticals, packaging . . . for tomorrow's surge of specialties . . . in new formulations, reactions and processes, nothing takes the place of Glycerine.

This balanced group of properties keeps Glycerine's usefulness growing

HYGROSCOPICITY • STABILITY • SOLVENT POWER • VISCOSITY • NONVOLATILITY • NONTOXICITY • TASTE • MW/HYDROXYL RATIO • HUMECTANT • CARRIER • SOLVENT • LUBRICANT • SOFTENER • EMOLLIENT • ANTI-FREEZE • ALKYD BASE •



☐ 20-page booklet on Glycerine for product conditioning

☐ 8-page booklet on "Federal Specifications for Glycerine"

☐ 16-page booklet on Glycerine properties and applications

☑ CHECK AND SEND FOR TECHNICAL DATA

For your free copy of any or all of these booklets write: **GLYCERINE PRODUCERS' ASSOCIATION** • 295 Madison Ave., New York 17, N. Y.

(Continued from page 28)

sumer outlets and the consumer himself. So does the automotive industry. One has the feeling though that the picture is not as black as it appears—the sleeping giant is slowly turning in his sleep. Research investments are rising somewhat—particularly those of the larger food producers. Management is beginning to look hopefully to research as a way out of this low profit corner. Dr. Charles Glenn King in a recent speech before the Chicago Section of the Institute stated that one of two major problems facing better nutrition in this country is the urgent need to get research represented at top management level in our food companies where they can engender the kind of philosophy and support necessary for nutritional planning in the years ahead. This must not be allowed to mean token representation—an "honorary" vice-presidency, for example—but a functional position, an actual voice in policy and planning.

Dr. Charles Glenn King . . . urges that research be represented at top level in food companies.

THE TECHNICAL MAN IN THE FOOD INDUSTRY

We come now to the technical man. We have examined the attitudes of his management. Now we shall examine the place of the man himself. The data on the technical man are taken from surveys which have a much broader scope than we would like. But we shall offer the responses—fully aware of the details that are smoothed out or are absent—as valid indicators.

Table 8, the median monthly salaries by fields of specialization, is from the recent ACS survey *(4)*. The study shows that the median is $606/month for chemists in the food industry. This median salary compares with $705/month for chemists in the fibre industry, the highest; and with $480/month for those working in the field of general chemistry, or basic science. The food industry ranked 18th in the order of monthly salaries. Basic science ranked 34th. Sewage and public health ranked 33rd.

Table 9, also from the ACS survey *(4)*, reveals the effect of seniority. In the food industry the median salary for those one year in the field was $407/month, increased to $458/month for those in the field 5.5 years, and rose to $682/month for those in the field 19.5 years. Then, there is a surprising drop for those in the field 39 years—$650/month. Note that this drop occurs in the other fields, too, organic chemistry, for instance; this is undoubtedly due to a certain inertia in regard to men already in the field as compared to the dynamic interest in new graduates—as the meteoric rise in beginning salaries will attest. Time will undoubtedly iron this out, though at the moment it is quite uncomfortable

(Continued on page 32)

TABLE 9[1]

1955 median monthly salaries for selected fields of specialization by years since entering profession and fields of employment

Field of specialization	Years since entering profession			
	1	5.5	19.5	39
Foods and kindred products, Chemistry	$407	$458	$682	$ 650
Organic chemistry (basic science) Chemistry	433	508	642	633
Petroleum, natural gas, and their products, Chemistry	566	533	830	1166

[1] *Chemical and Engineering News.* "The 1955 Professional and Economic Survey of the Membership of the American Chemical Society." Page 1768. Table XIX.

TABLE 8[1]

1955 median monthly salaries by fields of specialization (Without regard to years since entering profession)

Field of specialization	Monthly salaries			Ranking order of monthly salaries		
	Chemistry	Chemical engineering	All other fields	Chemistry	Chemical engineering	All other fields
Fibers, synthetic	$705	$717	$835	1	8	2
Foods and kindred products	606	686	691	18	12	22
General chemistry (basic science)	480	....[a]	477	34	....	34
Organic chemical technology	699	770	828	2	3	7
Public health, including water, sewerage, and sanitation	522	622	631	33	27	27

[a] Insufficient number reported to compute this measure.

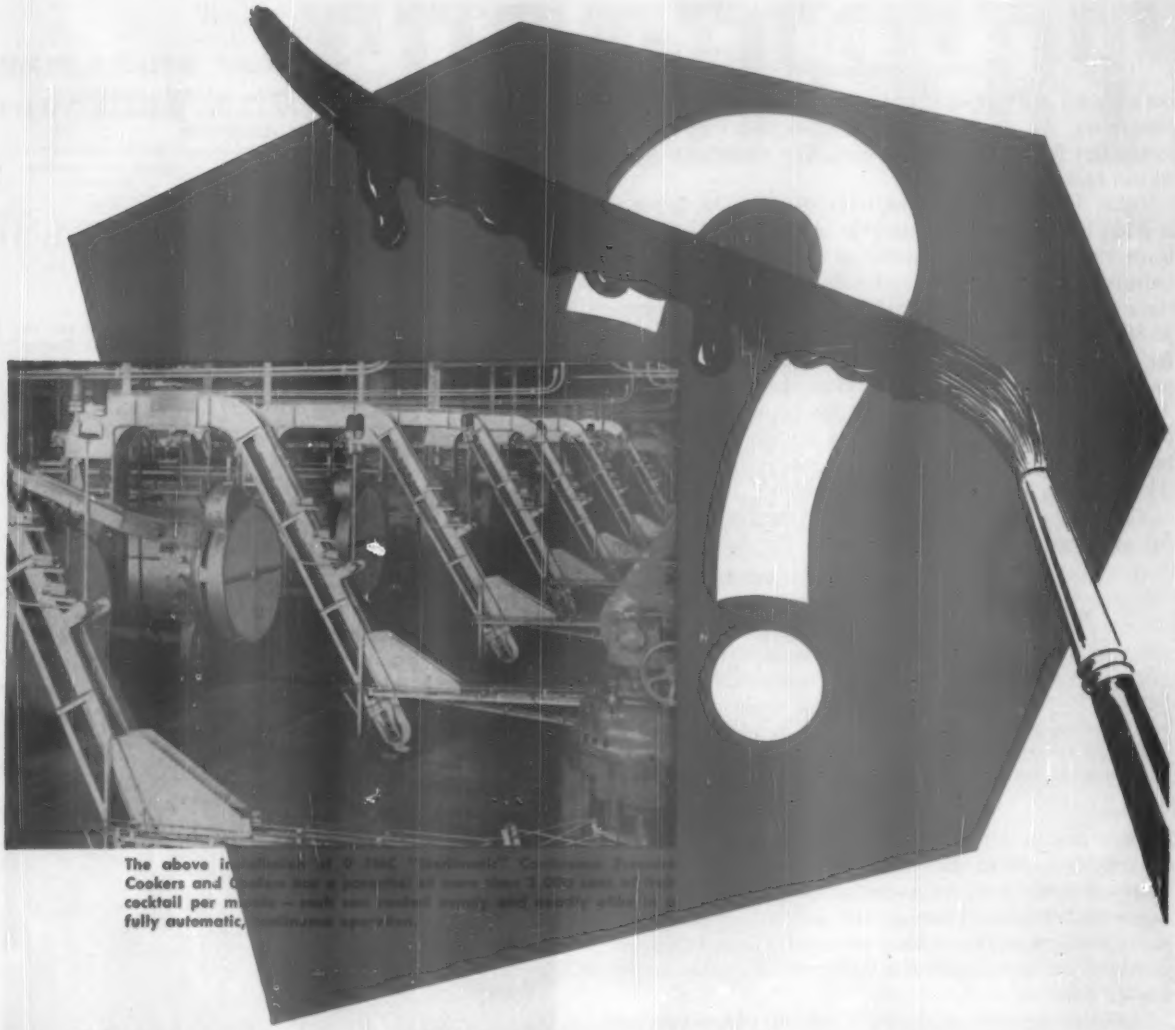
[1] *Chemical and Engineering News.* "The 1955 Professional and Economic Survey of the Membership of the American Chemical Society." Page 1766. Table XVIII.

TABLE 10[1]

Median income of chemists, by age, level of education, and industry, 1951

	Food and kindred products	Paper and allied products	Machinery (except electrical)	Electrical machinery	Professional and scientific instruments	Petroleum refining	Business and consulting services
Ph.D.							
All age groups	$8,700			$7,100			$9,600
Master's Degree							
All age groups	5,800	5,600			6,200		
Bachelor's Degree							
All age groups	4,800		4,700			5,600	

[1] "Manpower Resources in Chemistry and Chemical Engineering." Pages 86 and 87. Table A-27.



The above in... Cookers and ... cocktail per m... fully automatic,...

Taking the Guesswork out of Commercial Processing

The "Sterilmatic"* in-can method of processing gives canners everything they need to maintain highest uniformity and quality standards with dependable regularity.

It literally takes the guesswork out of sterilizing and quality control. Now canners control time periods and temperatures to predetermined measurements of unbelievable accuracy. Instruments and controlling devices allow any selective degree of temperature to be maintained with utmost dependability. The continuous flow of canned foods is fast, smooth and gentle. Efficiency is unmatched. Product texture, taste, color and nutrients are preserved as with no other cooking method.

See how the FMC "Sterilmatic" Continuous Pressure Cooker and Cooler can fit into your present operations. Just call your nearest FMC representative, or write for full information. There's no obligation.

*Trade Mark—Reg. U.S. Pat. Off.

FOOD MACHINERY
AND CHEMICAL CORPORATION
Canning Machinery Division

General Sales Offices: WESTERN: SAN JOSE, CALIF. • EASTERN: HOOPESTON, ILL.

(Continued from page 30)

not only for the long-timers but also for the employing companies. In the latter instance, loss of a long-timer to another industry or loss of morale in those who stay on can be a problem.

Table 10 one of the most interesting in the group, is from the Manpower Resources study *(2)*. Here we learn the effect upon income of higher degrees and industry chosen. In the food industry the median income for chemists is $8,700/year for the Ph.D. level, $5,800 for the Master's level, and $4,800 for the Bachelor's level. For the sake of quick comparison, the lows and highs have been extracted from the mass of data. The top figure is $9,600 for the Ph.D. working in the consulting field; the low figure is for the holder of a bachelor's degree, working in the machinery industry. The other highs and lows are also given.

The manpower study *(2)* also gives figures for chemical engineers. Table 11 establishes the fact that the

TABLE 11[1]

Median income figures for chemical engineers between the ages of 30 and 35

Industry	Median income
Food and kindred products	$5,300
Paper and allied products	5,300
Petroleum refining	6,000
Engineering and consulting services	6,900

[1] "Manpower Resources in Chemistry and Chemical Engineering." Page 51.

median income for chemical engineers in the food industry, ages 30 to 35, is $5,300. The same median salary is paid by the paper industry, but $6,000 is the figure in petroleum refining, and $6,900 is the median in engineering and consulting services. These data were collected in 1951, and the medians are presumably higher now.

Table 12, again from the ACS Survey *(4)*, points the path that should have been taken for those interested in higher income skills. Those in the field of chemistry for 39 years could have attained median salaries per month as administrators of $992. In production the median is $900. In basic research it is $650. In University teaching it is $590. For analysis and routine testing the median is $517. It should be recognized that these figures are for chemists, and that most of them were in the chemical or petroleum field. Yet, one cannot help but suspect that the same general level applies in the food field. The money lies in administration and

TABLE 12[1]

1955 median monthly salaries for selected occupational statuses by years since entering profession and fields of employment

Occupational status	Years since entering profession
	39
Administration, technical chemistry	$992
Analysis and testing chemistry	517
Production chemistry	900
Research in basic science chemistry	650
Teaching, college or university chemistry	590

[1] *Chemical and Engineering News.* "The 1955 Professional and Economic Survey of the Membership of the American Chemical Society." Page 1765. Table XVI.

production for technical men. Teaching and routine analysis are needed, but they are skills with less financial reward.

What is happening?

On the basis of this picture, what is happening to the technical man in the food field? Certainly he is more difficult to procure. There is no relief in proselyting those in other fields, and the task of influencing young people to go into our field becomes no easier. The ACS Survey *(4)* tells us unmistakably that we are a minus field. When the survey was made in 1941,

IFT Section meeting . . . interest in food science and technology is at a high level.

we had 6.0% of the chemists surveyed. The survey of 1955 reveals that we have lost ground. We now have only 4.6%. Other fields have lost men, too, such as organic chemistry, where a drop from 7.7% to 5.0% is registered. It seems evident, however, that organic chemists have stayed in the chemical field and have merely shifted to another phase. One gets the feeling

(Continued on page 34)

TABLE 13[1]

Fields of specialization in 1941 and 1955 by fields of employment

	All members			Chemistry						Chemical engineering			All other fields		
				Females			Males								
	1941	1955	Increase or Decrease	1941	1955	Increase or Decrease	1941	1955	Increase or Decrease	1941	1955	Increase or Decrease	1941	1955	Increase or Decrease
	Percent			*Percent*			*Percent*			*Percent*			*Percent*		
Plastics and synthetic	3.9	7.4	+3.5	0.9	3.4	+2.5	4.3	7.8	+3.5	4.7	8.8	+4.1	0.9	5.5	+4.6
Organic chemistry	7.7	5.0	−2.7	13.1	7.9	−5.2	10.6	7.5	−3.1	0.2	0.1	−0.1	0.9	0.6	−0.3
Foods and kindred products	6.0	4.6	−1.4	9.1	5.0	−4.1	6.1	4.3	−1.8	4.2	3.2	−1.0	7.4	7.2	−0.2
Agricultural chemistry	—	0.9	+0.9	—	1.0	+1.0	—	1.1	+1.1	—	0.1	+0.1	—	0.8	+0.8

[1] *Chemical and Engineering News.* "The 1955 Professional and Economic Survey of the Membership of the American Chemical Society." Page 1749. Table X.

*

EXPLORING NEW HORIZONS WITH

FROEDTERT

Where research is unlocking the secrets of barley malt

* FOR FOOD
* FOR BEVERAGES
* FOR INDUSTRIAL USE
* FOR ANIMAL FEED

Scientific control of malting helps food processors capitalize on natural flavoring and coloring — With consumers becoming more and more conscious of food product ingredients, many processors have discovered they can make their products more saleable by using Fro-Malt, a natural and healthful food in itself, for flavoring and coloring. And they've discovered that Froedtert's recently expanded research and production facilities offer superior service with malt to meet their exact analyses and specifications. In fact, Froedtert invites food technologists to avail themselves of these facilities in cooperative programs to develop types of Fro-Malt custom-formulated to specific requirements.

Wide range of Fro-Malt applications as a flavoring agent — Available as a flour (in varying degrees of fineness) or in pulverized, crushed or whole grain form — Fro-Malt can be produced with qualities covering a broad flavoring range. Generally speaking, Fro-Malt with strong flavor characteristics is darker in color than blander varieties of Fro-Malt. However, strongly flavored malts can perform their function in quantities so small that there is little effect on final product color.

While there is no generally accepted yardstick of rating flavor strength, Froedtert has the experience and facilities to work with food technologists to produce pilot quantities of Fro-Malt . . . comparing its relation to final characteristics desired . . . and then producing it in quantity that perfectly matches the characteristics of the pilot batch.

Highlighting Fro-Malt as a coloring agent — Froedtert offers "second to none" facilities for supplying food processors with barley malt to meet any coloring requirement within the Lovibond range. Thus, with Fro-Malt, food processors have an opportunity to take advantage of the benefits of a "natural" coloring agent and at the same time build-in added nutrient value.

Froedtert has extensive facilities to handle pure research in malt applications — Nerve center of Froedtert's research effort is located in the pilot malting laboratory. Here — through use of advanced types of electronic and pneumatic controls and equipment — the research staff can maintain precise temperatures, exact moisture content and instantaneous control of all functions relating to the process of malting. This finite control, plus ability to duplicate exact sets of variables, allows Froedtert to reach previously impossible high levels of accuracy, uniformity and reliability.

Fro-Malt is available in many forms — for flavoring . . . coloring . . . to promote enzymatic action or add food value . . . and in some cases for use as a preservative. Contact Froedtert now to see how malt may be able to improve your formulation or processing.

FROEDTERT MALT CORPORATION

FROEDTERT *Malt Corporation*

Milwaukee 1, Wisconsin

(Continued from page 32)

that in the food field, the "drops" have been out of the field entirely. This feeling gains support from several sources. A large trade magazine in the food field regularly surveys its subscription drops in an effort to find out why. It has magazines in several other fields. The response—"left the field"—is by far the most common from those dropping the food magazine. Further, a study of IFT membership drops by our Executive Secretary has shown that about 10% of our membership drops out each year. Fortunately, we have a young and vigorous organization; not only do we cancel out the drops, but new members permit us to grow at a rate of 7 to 10% a year. Interest in food science and technology stays at a high level. Other association drop figures are not available, but it would be interesting to compare ours with those of organizations which, like the Institute, are single-industry oriented.

CONCLUDING COMMENT

In closing, here are some highly applicable remarks: "Modern conditions demand the utmost efficiency in order to meet competition and to enable a manufacturer to discharge his responsibilities in the fullest sense to the consumer. This can only be achieved by adopting a management structure which makes the fullest use of the scientist in assisting in both the control and development product, and this demands some change of attitude not only by production management but also by the scientists themselves."

"By no means all firms in the food industry fully appreciate the value as yet of technology and the importance of the scientist.

"The stress of modern competition on the one hand, and the prevailing shortage of labor and the rapid strides made in new techniques, on the other, should alter this attitude fairly rapidly."

The foregoing excerpts are from an address given by a prominent British industrialist, Mr. M. C. Carr, before the Society of the Chemical Industry. They indicate that attitudes and problems have much the same ring the world over. When the facts are in, the true dimensions of our problems will be known. Results of the Institute survey will not solve these problems but they should help to chart a course of action.

LITERATURE CITED

1. Anonymous. Science and engineering in American industry. National Science Foundation. Pub. by U. S. Department of Labor. Supt. Doc., Wash. 25, D. C. (1955).
2. Anonymous. Manpower resources in chemistry and chemical engineering. Bull. No. 1132, U. S. Dept. Labor, Supt. Doc. Wash. 25, D. C. (1953).
3. Dearborn, D. R., Kneznek, R. W., and Anthony, R. N. Spending for industrial research. Harvard University, Graduate School of Business Administration, Cambridge, Mass. (1953).
4. Fraser, A. Professional and economic survey of the membership of the American Chemical Society. *Chem. Eng. News*, April 9, 1956, pp. 1731-1792. (1956).

OPEN HOUSE AT RUTGERS

The Department of Food Technology, Rutgers University, held Open House, Friday, November 23, 1956, for senior high school science students in New Jersey. Forty-two students and seven science teachers took a day out of their Thanksgiving period to attend. Eleven food companies cooperated by financing the expenses of students from the high schools located in their respective vicinities. The New Jersey companies (or affiliates) participating were:

American Cyanamid—Princeton
E. F. Drew and Co.—Boonton
Food Fair Stores, Inc.—Linden
Fiddler's Creek Farm—Pennington
Hilder's Finer Food—Flemington
Kent's Restaurant—Atlantic City
Merck and Company—Rahway
Monmouth Cold Storage Co.—Neptune
Preservaline Manufacturing Co.—Flemington
Seabrook Farms—Seabrook
R. S. Watson & Son—Greenwich.

ANNUAL MEETING ANNOUNCEMENTS . . .

PITTSBURGH, 17TH ANNUAL MEETING SITE, A DIVERSIFIED RESEARCH CENTER

Members bound for the 17th annual meeting of IFT in '57 (May 12-16) have a surprise in store for them. Those who read the "profile" of Pittsburgh in the November issue have already learned that the city is no longer a smoky coal and steel milltown. Aside from undergoing a physical renaissance, Pittsburgh has become an important, expanding, diversified research center. The spectrum of research activities stretches from metallurgy to medicine, gasoline to glass, steel to starch, fuel to food technology.

Fifty Major Centers. In the universal race to make people and products better, the Pittsburgh area has achieved worldwide prominence—first, as a focus for industrial research, a natural consequence of the concen-

(Continued on page 36)

Artist's Model—New Schools of the Health Professions

Because...

the best products you can make depend on the best ingredients you can buy...

LOOK TO Sterwin FOR-

VITAMINS

Essential vitamins by *STERWIN* U.S.P. . . . in bulk and specially prepared carriers . . . quick delivery . . . any quantity, any time. Quality control under constant direction of experienced specialists assures potency, purity, dependability of *each individual batch.*

Parakeet® CERTIFIED F.D.& C. COLORS

A complete line of pure colors. Leaders in basic color field for more than 25 years. *PARAKEET COLORS* add eye and sales appeal to many famous food and drug products. Carefully controlled manufacture, rigid laboratory testing guarantee top quality colors. Any shade or color combination desired can be produced.

For Further Information on Sterwin Products Write:

ZIMCO® U. S. P. VANILLIN

Made by world's largest producer of Vanillin. Exquisite flavor and delectable aroma. *Pure* . . . only U.S.P. pure crystals, giving true, vanilla-like flavor. *Soluble* . . . dissolves quicker due to uniform crystalline structure. *Uniform* . . . flavor never varies—use *ZIMCO* as a standard in determining your formula. *Availability* . . . unlimited supply of basic material—ample plant capacity.

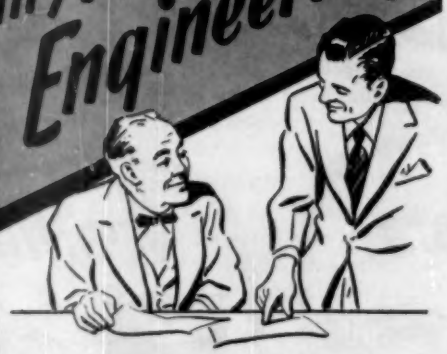
STERWIN HELPS STOP YOUR SANITIZING PROBLEMS with ROCCAL®
The Original Quaternary Ammonium Germicide. Provides industry with an effective germicide that is laboratory controlled and tested.

STOCKED FOR QUICK DELIVERY AT: [illegible]

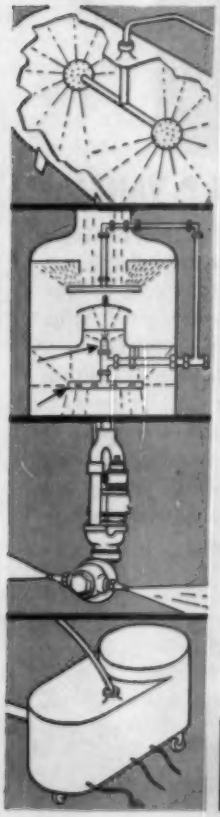
Sterwin Chemicals INC.
Subsidiary of Sterling Drug Inc.
1450 BROADWAY, NEW YORK 18, N. Y.

KLENZADE

Technical Service in Automation Engineering



LAYOUT, EQUIPMENT and DETERGENTS FOR AUTOMATION CLEANING



Spray Balls

FOR STORAGE TANKS

Custom-engineered by Klenzade to meet the sanitary needs of each particular installation. Another Klenzade "first" — pioneered and developed by Klenzade field and technical staffs.

Spray Arms

FOR EVAPORATORS

First in the field with job-engineered spray arms for automation pan and evaporator cleaning. A real contribution to higher sanitation standards and lower costs.

Rotor-Jet

FOR BULK PICK-UP TANKS

Complete automatic program timing. Only minutes required for a thorough cleaning. Technique originated by Klenzade.

Re-Circulating Unit

FOR HIGH TEMP EQUIPMENT AND CIP CLEANING OPERATIONS

KLENZADE PRODUCTS, Inc.

BELOIT, WISCONSIN

(Continued from page 34)

tration of the so-called heavy industries in the area, and second, as an up and coming medical and education center. Today, some 6000 scientists and technicians in 50 major local centers depend on research work for their livelihood. About 35 million dollars worth of new research buildings are now being added by industry alone. This is in addition to the expansion taking place at the universities and Medical Center — where seldom-equalled civic-minded philanthropy has flourished. In the last few years nearly 50 million dollars in new structures have been directed to patient care, research and education. It is here that painstaking investigative effort has recently given the world the Salk polio vaccine.

Dr. Jonas E. Salk, Director, Virus Research Laboratory, Pitt Health Center.

Mellon Institute. It all started with the founding of the Mellon Institute of Industrial Research in 1913. Today, the Ionic columns of this landmark house fellowship research for over 80 major sponsor companies as well as government agencies and foundations. Pivoted about the Institute, in a ring of 30 miles, are the research centers of industry. Here also are the U. S. government laboratories of the Bureau of Mines.

Big steel has its research laboratories here, and the field of investigation is by no means limited to ore utilization and steelmaking. Basic high temperature work, essential in the missile program, and coal-chemical research is being carried out side by side with investigations into new methods of tinplating for cans. In producing steel today alloying elements that impart special qualities are required and an immense amount of research has gone into the development of stainless steel, heat resistant steel, steel with improved magnetic properties and the wide range of versatile steels required by a whole new era of science and technology—an era that has witnessed the most dramatic industrial expansion of all time. Research and technology in the coal industry is equally progressive. The U. S. Bureau of Mines has over fifty projects under way, a 60 million dollar research program including such experimentation

(Continued on page 38)

Mellon Institute

If It Hadn't PROVEN ITSELF...

We Wouldn't Be Shouting About This Wonderful

new *flavor* FOR CAKE MIX

It's well and good for a firm to believe its new product will accomplish the desired results. But the actual proving is done by customers.

Our customers are sending in repeat orders for Vanilla Laboratories Special Cake Mix Flavor.

This new, *complete* flavor is made exclusively by our specialists. By variations of the basic flavor (Pure Vanilla and other flavoring ingredients), we can furnish each Cake Mix its own distinctive flavor—tailor-made yet budget-priced.

We would be glad to tell *you* all about it.

Originated by Specialists Working Within a Specialized Firm

Basic Flavors *Individualized* **For Each Cake Mix**

SPECIAL PRODUCTS DIVISION

VANILLA LABORATORIES, Inc.

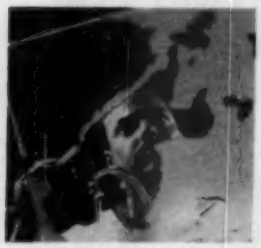
ROCHESTER, N. Y.

SPECIAL FLAVORS FOR PREPARED CAKE MIXES, PREPARED ICINGS AND PUDDINGS

(Continued from page 36)

as gasifying coal in its underground site and the development of synthetic fuels through hydrogenation.

Gulf Oil Company's nearby petroleum research center is considered the most highly integrated and complete unit of its kind in the world. It combines geophysical and geological research with petro-chemistry and basic physics, in an almost campus-like setting.



Soap Bubble "Atoms" Show Basic Structure of Matter

Sixty acres surround the research and development headquarters of the Aluminum Company of America, where about 500 men and women are engaged in every conceivable phase of investigation—new ways of producing the metal, new uses, improvements in refining and reduction, etc. Westinghouse Electric expects to dedicate its mammoth research headquarters here soon, and already many of the 500-man staff are there at work.

Food Research. In the field of food research and technology, the H. J. Heinz Company is building a new 5 million dollar model research center which is scheduled for completion in the fall of 1957. The finished laboratories and pilot shops will make this one of the most advanced units of its kind, with facilities for both basic research and applied product and process work.

Westinghouse's New Research Laboratories

Government-sponsored food research is conducted in another famous Pennsylvania city, Philadelphia, where the Eastern Regional Research Laboratory, U. S. Department of Agriculture, is located.

The list is longer; it covers glass, chemicals, plastics, paint, and nucleonics. It becomes apparent that research, once the stepchild of production, is gradually assuming a place nearer the head of the table. And nowhere has this been better demonstrated than in Pittsburgh, Pennsylvania—Research Center of America.

FOOD INDUSTRY TOPICS . . .

. . . by Norb Leinen

. . . in the public interest

Engineers and other professional employees are earning about 8.6% more than last year, according to a survey just distributed to its subscribers by the Executive Compensation Service of American Management Assn., 1515 Broadway, New York 36, N. Y. The 8.6% over-all average increase in annual compensation compares with an increase of about 4.5% for the previous year. The percentage rise in engineers' salaries is higher than that shown for any other executive and specialized groups whose pay the Executive Compensation Service studies. These groups include administrative and technical personnel, top management, middle management, and sales personnel. Highest salaries reported are being paid to certain non-management specialists in research and exploration with some administrative duties. In a few cases, these individuals are earning as much as $19,000 a year. Physicists and mathematicians with similar administrative duties average up to $15,000 a year. In the top range of the technical and professional group, the pay levels tend to overlap with those of middle management. However, the engineers and scientists are much less likely to receive bonuses than are the members of middle management.

Findings reported recently by the Hygienic Guides Committee of the American Industrial Hygiene Association indicate the remarkable safety and use of an all-but-unknown solvent material—methyl chloroform. The solvent, commercially available only recently, looms as a substitute for the dangerous carbon tetrachloride. Although almost identical in physical and cleaning properties, it has been shown to be much less likely to injure the user in almost every application where hand cleaning at room temperature is done. General ventilation is considered sufficient for brief exposures or those resulting from very small quantities of the solvent. With prolonged exposures or with elevated temperature operations, process ventilation is required. Recommended maximum atmospheric concentration (8 hours) for methyl chloroform is 500 parts of vapor per million parts of air, by volume, while that for carbon tetrachloride is 25 ppm. Concise control standards for human exposure to ethyl alcohol, hydrogen fluoride, mercury, trichloroethylene, and 1,1,1,-trichloroethane (methyl chloroform) are given in the recent issue of the Association's "Hygienic Guide Series." Hygienic Guide sheets on each substance may be obtained from the Association, 14125 Provost, Detroit 27, Mich., at 25c each, prepaid.

Food Industry's finest flavor policy

Atlas Fruit Flavors are available in various strengths and concentrations. They are also available expertly blended with synthetics to insure lasting taste and aroma. Let us suggest the Atlas flavor best suited to your requirements.

FIRST PRODUCERS OF CERTIFIED COLORS

H. KOHNSTAMM & COMPANY Inc.

ESTABLISHED 1851

89 PARK PLACE. NEW YORK 7 • 11-13 E. ILLINOIS ST.. CHICAGO 11 • 2632 E. 54 ST.. HUNTINGTON PK.. CALIF.

BRANCHES IN OTHER PRINCIPAL CITIES OF THE U.S.A. AND THROUGHOUT THE WORLD

A 20% discount is allowed on orders of 5 or more Guides; 40% on orders of 100 or more.

A Cinderella industry now on the threshold of its second decade is the aerosol, which, for 1956, is expected to add up to a third of a billion cans and some $350 million in sales. New aerosol markets for drugs, pharmaceuticals, cosmetics, and allied products are being investigated. In foods alone, according to W. E. Graham, research manager of Crown Cork & Seal Company's Can Division, Philadelphia, who also is chairman of the research committee of the Can Manufacturers Institute, experiments are under way to determine whether there is a future for aerosols in such products as catsup, sandwich spreads, cooking oil, mayonnaise, sauces, and peanut butter. He foresees the time when the hostess will be able to go to her handy aerosol food-shelf and "spray" an entire tray of hors d'oeuvres and canapes minutes before her guests arrive.

Southern Research Institute, Birmingham 5, Ala., has begun research on two new projects in food packaging for the Quartermaster Food and Container Institute for the Armed Forces, Chicago. These projects deal with use of plastic packages to contain food for sterilization or pasteurization by irradiation with gamma rays. Broad objectives of the project are to study the effects of radiation, in the presence of foods, on the protective properties of the packaging material, and to study the effect of the packaging materials on the foods being irradiated. SRI is continuing a study for the F&CI on the chemistry of flavor changes taking place in meat as the result of irradiation sterilization.

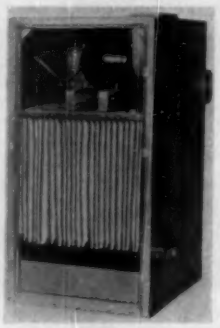
. . . *things new under the sun*

The first commercial fermentation production of lysine, one of the 8 amino acids considered essential to human nutrition, has been announced by Chas. Pfizer & Co., Inc., 630 Flushing Ave., Brooklyn 6, N. Y. The development, representing a significant breakthrough in biochemical engineering, was made possible by the fermentation techniques with which Pfizer also manufactures vitamins, antibiotics, hormones, and other chemicals. These techniques provide a high purity product free of D-lysine—a form of the important nutrient which cannot be used by the body. Pfizer's Chemical Sales Division will market the essential amino acid in the form of L-Lysine Monohydrochloride. The pure white, crystalline, 80-mesh powder, with a guaranteed potency of not less than 98%, will be priced from $12 per pound in 50-pound lots, to $14 per pound in one-pound lots.

A new form of vitamin E offering many advantages to pharmaceutical manufacturers and food processors is offered by the Vitamin Division of Hoffmann-LaRoche Inc., Nutley, N. J. Available "by the tons" as are other Roche vitamins, the dry vitamin E acetate powder 25% contains 250 International Units of vitamin E per gram. All components of the granule are easily digested so that the vitamin E biological activity is fully available. The powder does not melt or liquefy at processing temperatures or when mixed with other vitamins, disperses in milk, fruit juices, and water, and maintains its potency, even when the solutions are kept for several days in household refrigerators. Price per International Unit is equivalent to oil types.

The internationally known, low-cost Goldberg Combination Hand and Dipping Refractometer—designed for the precise, rapid, and easy determination of the total soluble solids in juices, jams, jellies, syrups solutions, and other food products—is offered by the Instrument Division of American Optical Co., Buffalo 15, N. Y. A unique optical system transmits a sharp division line from light to dark onto a large 0.5% graduated scale contained in the focusable eyepiece. Metal parts are corrosion-resistant, easy to clean, and protect optics from damage. The water-tight prism assembly permits immersion into solutions for dipping method and prevents seepage into the internal system. A thermometer, ranging from 10° to 40° C., recessed in the prism mounting, increases accuracy by measuring actual temperature of sample and instrument rather than surrounding air. Two models are available in Brix ranges 0 to 47% or 45 to 75% soluble solids.

All Torit "Series 80" cabinet cloth-filter dust collectors have been redesigned to permit over 2½ times more dust storage capacity, according to announcement by Torit Mfg. Co., 287 Walnut St., St. Paul 2, Minn. Three models—81, 83, and 84—are affected by the change, which will jump the capacity of each collector from ¾ cu. ft. to 2 cu ft. Each of the units has 150 sq. ft. of cloth filtering area, with filters made from fine-woven cotton, chemically treated for spark resistance, and each cabinet measures 49¼" by 28¼" by 28". Internally mounted motors and fans move from 580 to 1100 cfm of air through the filters at speeds of 5,000 to 8,000 fpm. Prices of the units range, as before the redesign, from $398 to $448, f.o.b. factory.



A new brand of sodium isoascorbate is being offered to the meat packing industry as a curing aid and antioxidant by Wallerstein Co., Inc., 180 Madison Ave., New York, N. Y., under the trade name of CURONA. A dry powder, stable at room temperature, soluble in water, colorless in solution, and neutral in taste, CURONA reportedly can economically replace sodium ascorbate or ascorbic acid to improve and speed up curing action to protect the color and quality of meat and meat products. Its use is recommended to shorten curing time, improve color, and cut down shrinkage of cured meats, and protect color, flavor, and quality of packaged meats. It is recommended particularly

in the treatment of sausage meats, frankfurters, ham, bacon, and luncheon meats.

The EVERPURE water purifier, Model T-9, a precoat type filter rather than a backwash granular bed type, when operated on Chicago municipal water, has a capacity on intermittent flow of approximately 10,000 gallons down to a flow rate of ½ gpm. To handle greater requirements, two or more Model T-9's may be placed in parallel. Two such units in parallel would double the initial flow rate of 5 gpm, double the filter area, and would deliver approximately 4 times the capacity, *i.e.*, 40,000 gallons. The Model T-9 is 16½" high and 9¼" in diameter. Write Tested Appliance Co., Inc., 2627 W. 19th St., Chicago 8, Ill.

Badger Mfg. Co., Cambridge, Mass., has announced successful completion of tests of its new multiple-stage flash distilling plant. The unit, designed to produce distilled water of very high purity from normal sea water, has been run for more than a month at International Nickel Company's test station at Kure Beach, N. C. At the end of the test period, the 4-stage unit was running well over capacity of 1,000 gallons of distillate per hour, while still producing water with less than ¼-grain per gallon total solids. The Badger unit successfully overcomes traditional difficulties such as the tendency to entrain sea water which results in product contamination. Its design also permits scale-free, trouble-free, completely automatic operation.

A new 5-micron (0.0002") filter cartridge made of white cellulose, bonded with a totally inert resin, is available from Cuno Engineering Corp., Meriden, Conn. The new "White MICRO-KLEAN" cartridge is recommended for filtration problems where fluid polishing to extreme clarity is required with no contamination of fluid or impairment of taste. The new cartridge, which fits most standard filter housings, handles highly alkaline fluids without contamination of the fluid or deterioration of the filter cartridge. "Graded density" construction traps out large particles early in the flow path, preventing plugging of the finer filter barriers that follow.

Heliogen® Sanitizer, a near-white powder which dissolves instantly in hard or soft water, forming a crystal-clear solution containing diatomic iodine, a non-toxic and powerful sanitizer, is announced by S. B. Penick & Co., 50 Church St., New York 8, N. Y. Fully effective in either acid or alkaline solutions and active at prevailing temperatures, summer or winter, the product is non-corrosive, nonirritating to the skin, and leaves no odor, taste, or film. It is equally effective against bacteria, viruses, and fungi, destroying these microorganisms within 15 seconds. Samples and further information are available.

. . . *the literary corner*

The latest article in the series "The Changing World of Food," appearing in *D&O News*, published by Dodge & Olcott, Inc., 180 Varick St., New York 14, N. Y., relates the story of the amazing Chlorella under the subtitle, "The Universally Well-Fed Future." The item is carried in the November 1956 issue.

An 8-page pamphlet on an antioxidant for a wide variety of chemicals, fats and oils, drying oils, etc., and also containing information on the mechanism of oxidation is available from Catalin Corporation of America, 1 Park Ave., New York 16, N. Y.

New Ace Rivicior chemical-resistant plastic pipe, fittings, and valves are described in 8-page bulletin CE-56, available free from American Hard Rubber Co., 93 Worth St., New York 13, N. Y.

Catalog 88, a new 100-page catalog of equipment and supplies for the meat industry, published by Koch Supplies, 2520 Holmes, Kansas City 8, Mo., contains more than 2200 items, with complete specifications, shipping weights, and prices.

A new booklet issued by Merck & Co., Inc., entitled "Why the 40-Plus Patient Needs More Vitamins," stresses the protection vitamins give the 40-and-over individual, particularly with reference to the circulatory, nervous, digestive, hemopoietic, skeletal, and endocrine systems. There are also selected abstracts from articles by nutritional and medical authorities, and a bibliography of 142 references. Interested nu-

SIX DECADES
OF SERVICE TO
FOOD TECHNOLOGISTS

60 years of specialized experience in the manufacture of powdered vanilla products

David Michael has long since mastered the special skills and techniques to create new and highly individual flavorings to fill any specific need, and have been the acknowledged leader in the vanilla field for 60 years.

Let us develop a custom-made flavor for your product in our laboratories and testing kitchen. Research is our keynote—let it work to your advantage!

DAVID MICHAEL & CO., INC.
3743-63 D Street • Philadelphia 24, Pa.
Suite 2204 • 203 N. Wabash Ave., Chicago 1, Ill.

CANADA
DAVID MICHAEL & CO., LTD.
801 St. Clarens Ave., Toronto

tritionists of vitamin-fortified food manufacturers can obtain a copy by writing to "40-Plus" Dept., Chemical Division, Merck & Co., Inc., Rahway, N. J.

◆ ◆ ◆

A review of current methods employed in code marking cans is contained in a new 8-page bulletin published by Triple-E Engineering Co., Racine, Wis. Featured is a detailed description of the new Dataline coding method, by which variably spaced scratches provide essential quality control information.

◆ ◆ ◆

New 2-page bulletin SCB 10-56, describing the new Seidel Calculating Board for evaluating photometric data from spectrographic films and plates, is offered by Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

◆ ◆ ◆

Bulletin No. 492, provinding "A Few Facts About Humidification for Industry," and describing a complete line of industrial humidifiers, is available from Abbeon Supply Co., 179-15A Jamaica Ave., Jamaica 32, N. Y.

◆ ◆ ◆

Formulas for 34 different fruit pie fillings are included in a booklet offered by Corn Products Sales Co., 17 Battery Pl., New York 4, N. Y. The 52-page booklet, "Snow Flake Milo Starch for Fruit Pie Fillings," is designed to assist large commercial and neighborhood bakers in use of the firm's two new Snow Flake milo starches, which reportedly possess unique gel characteristics.

◆ ◆ ◆

"Symbolic Logic, Binary Calculation, and 3C-PACs," a 16-page booklet described as a primer on the subject of digital computation, is available free from Computer Control Co., Inc., 92 Broad St., Wellesley 57, Mass.

◆ ◆ ◆

Detailed description, operation, and service of push-type semi-automatic lubricators are included in a 2-page, 2-color service instruction sheet offered by Bijur Lubricating Corp., Rochelle Park, N. J. Two models of Bijur's "one-shot" lubricators, widely used on machines requiring closely controlled but infrequent oil feed, are described. Model HIA has a one-pint capacity reservoir; Model JIA a two-pint capacity reservoir. Both units are actuated by a spring discharge piston pump that feeds oil into a distribution system to lubrication points.

◆ ◆ ◆

A booklet, "The Scientific Nibble," is available from Sugar Information, Inc., New York 5, N. Y.

. . . *meeting hall and conference room*

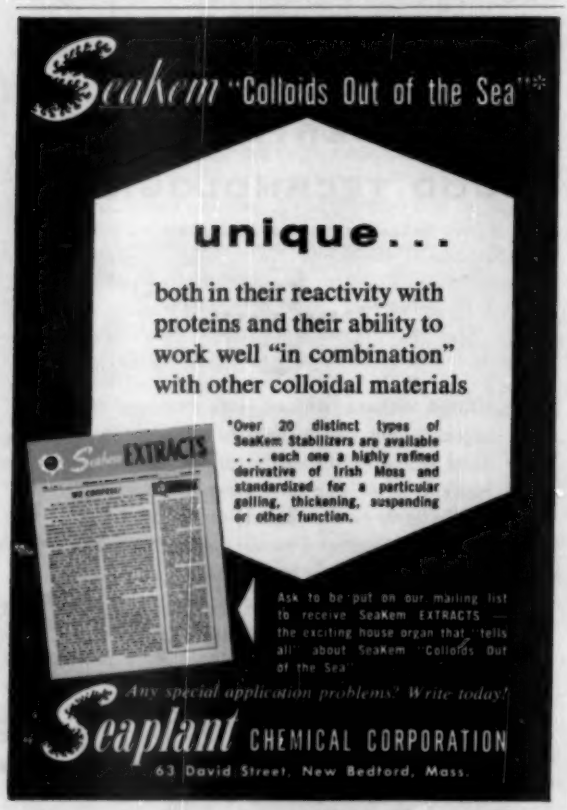
Midwest Preservers Assn., at its first annual meeting October 24 in the Lake Shore Club, Chicago, elected the following officers: President, Francis J. Oelerich, Oelerich & Berry Co., Chicago; Vice President, Richard D. Fellows, Squire Dingee Co., Chicago; Secretary, Gordon Perry, Holsum Products, Milwaukee; Treasurer, Geo. Levison, Orchard Products Co., Chicago. Midwest Preservers Assn., a regional associate of National Preservers Association with headquarters in Washington, D. C., is one of six groups now functioning. Others are located in New York, Boston, Atlanta, Los Angeles, and San Francisco.

◆ ◆ ◆

More than 500 members of the National Pickle Packers Association met in Chicago's Edgewater Beach Hotel for the group's second annual Pickle Fair on October 17-19. In addition to a schedule of sales, field, and production seminars, NPPA members observed the latest developments in the largest exhibition of pickle-making and pickle-packing equipment ever gathered together under one roof. The first NPPA "Hall of Fame" award, an engraved silver platter, was presented to Dr. J. L. Etchells, USDA Laboratory, Raleigh, N. C., in recognition of his outstanding contribution to the advancement of the pickle industry. The Association's next annual meeting is scheduled for April 18-19, 1957, at the Drake Hotel, Chicago.

◆ ◆ ◆

At the October 23-26 annual meeting of the Association of Food Industry Sanitarians, held in Monterey, Calif., the technical sessions were featured by five panel discussions. There were: "College Curriculum for Food Industry Sanitarians," "Maintenance and Repair of Surfaces and Surface Coatings," "Sanitary Design of Food Processing Equipment," "Advances in Sanitation as Related to Food Processing Industries" and "Food Plant Waste Disposal." Re-elected for a second year were the following officers: President, Prescott R. Lloyd, C&H Sugar Refining Corp., San Francisco; Vice President, Clayton L. Baldwin, Jr., Exchange Lemon Products, Corona, Calif.; Executive Secretary-Treasurer, Paul E. Laughlin, Dried Fruit Assn., San Francisco.


SeaKem "Colloids Out of the Sea"*
unique...
both in their reactivity with proteins and their ability to work well "in combination" with other colloidal materials
*Over 20 distinct types of SeaKem Stabilizers are available . . . each one a highly refined derivative of Irish Moss and standardized for a particular gelling, thickening, suspending or other function.
EXTRACTS
Ask to be put on our mailing list to receive SeaKem EXTRACTS — the exciting house organ that tells all about SeaKem "Colloids Out of the Sea"
Any special application problems? Write today!
Seaplant CHEMICAL CORPORATION
63 David Street, New Bedford, Mass.

. . . *building up and branching out*

A unique feature in the expansion and modernization of Ungerer & Co., Inc., New York City, is the mezzanine floor added to the firm's New York branch warehouse, providing new space for packaging and shipping facilities. The firm's sales and executive offices are located in the same building.

Magnus, Mabee & Reynard, Inc., 16 Desbrosses St., New York 13, N. Y., announce appointment of Harold Davis & Co., 824 Notre Dame St.W., Montreal 3, Quebec, as Canadian agents for the sale of MM&R products to the confectionery industry exclusively.

David P. Reynolds (right), vice president in charge of sales, Reynolds Metals Co., Louisville, Ky., presents "The President's Award," top honor of the National Flexible Packaging Competition, to Donald B. Lourie (center), president, The Quaker Oats Co., Chicago, and Raymond Loewy, president, Raymond Loewy, Inc., New York City. The Aunt Jemima Corn Bread Mix package of Quaker Oats Company—designed by Raymond Loewy, Inc., and produced by Reynolds Metals Co., Packaging Division—won on its high rating in design, merchandising impact, and functional performance.

The Pacific Coast's first petrochemicals plant producing ethylene oxide, ethylene glycol, and polyethylene now is running at full scale according to announcement by Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17, N. Y. The Torrance, Calif., plant, located on a 140-acre site, consists of highly specialized equipment unlike anything in the area. Conversion of petroleum gas into chemicals is carried on in tanks, towers, and miles of pipe. Much of the gas is brought in from the neighboring General Petroleum Co. Production processes at the 350-employee plant are largely controlled by automation and continue on stream 24 hours a day. Of special interest to people in the area is the company's positive approach to the problem of air pollution. Carbide and Carbon followed recommendations made by the Los Angeles Air Pollution Control District in regard to installing devices that dispose of unused gases without polluting the air.

Chas. Pfizer & Co., Inc., 630 Flushing Ave., Brooklyn 6, N. Y., has announced two new openings. Its new manufacturing plant at Arnprior, Ontario, will package such drugs as Terramycin and the new antibiotic combination, Sigmamycin, for the Canadian market. Located on an 80-acre site on the Ottawa River, 40 miles from the Canadian capital, it is one of Pfizer's 17 plants outside the U. S. completed or now under construction. The firm's new Midwestern Distribution Center at 6460 W. Cortland St., Chicago (shown above), officially opened on October 24, will serve customers in a 15-state area. The new 2-story modern structure contains 79,000 sq. ft. of warehouse space, part of it air-conditioned for storage of heat-sensitive chemicals and drugs. Offices and a lunch room, all on the second floor, cover an area of 20,000 sq. ft. and also are air-conditioned. The center has 3 freight-car loading docks and 5 truck loading docks. All four of the company's domestic marketing divisions—Pfizer Laboratories, J. B. Roerig & Co., Chemical Sales, and Agricultural Sales—will have their regional headquarters in the new center.

The Froedtert Malt Corp., 3830 W. Grant St., Milwaukee, Wis., is making available its research facilities to food technologists, pharmaceutical scientists, chemists, and other researchers in industry who feel that malt may aid them in making a better product. The firm pointed out that research experts are being added to the staff of the half-million dollar Froedtert Laboratories, in addition to studies by outside re-

look for the symbol of the RETORT
YOUR GUARANTEE
OF MATCHLESS QUALITY,
PURITY, UNIFORMITY
Behind the symbol of the Retort stands three generations of family pride and "know-how" in Essential Aromatics, natural and synthetic flavors, perfumer's specialties. Made in the West's most modern plant. The Retort is your guide to dependability.
F. Ritter & Co.
Los Angeles 39, California
Branch Offices in Principal Cities

search consultants. Simultaneously, the company announced it is launching a broad advertising, merchandising, and public relations program to both the consuming public and the research scientists. First step in Froedtert's program has been to create a new trade name, "FroMalt," for its product, barley malt.

. . . the human element

Appointment of **William J. Hoover** as manager of technical services has been announced by Corn Industries Research Foundation, Inc., 1001 Connecticut Ave., N. W., Washington 6, D. C.

◆ ◆ ◆

A. N. McFarlane, general sales manager of Corn Products Refining Co., 17 Battery Pl., New York 4, N. Y., recently announced appointment of four regional sales service managers—**C. J. McDowell, R. F. Cohee, R. D. Walter,** and **E. W. Beardsley**—named to these positions in the Eastern, Central, Southern, and Western Divisions, respectively. They will make their headquarters in the company's Sales Division offices in New York, Chicago, Memphis, and San Francisco.

◆ ◆ ◆

Richard A. MacWhorter has been appointed sales manager, and **Edburt L. Timm** has been promoted to technical director of Pulverizing Machinery Division of Metals Disintegrating Co., Inc., Summit, N. J. The division manufactures pulverizing, pneumatic air conveying, and dust collection equipment. Mr. MacWhorter had been assistant industrial sales manager with Henry Disston Sons, Inc., Philadelphia, now a division of H. K. Porter Co., Inc. Mr. Timm joined the company in 1934, becoming assistant sales manager in 1953 and sales manager in 1954. As technical director, he will be in entire charge of the firm's engineering activities, including research, development, servicing, inspection, and testing.

◆ ◆ ◆

Dr. Edward E. Anderson, treasurer of the Northeast Section of IFT, has joined the staff of the Flavor Laboratory of Arthur D. Little, Inc., Cambridge, Mass. Well known for research on various phases of canning, freezing, and nutrition, he comes to ADL from the University of Massachusetts, where he was associate professor of food technology. His experience includes eight years on the University faculty and two years as a federal food inspector with the War Food Administration in California. He has authored over 30 technical papers.

. . . Anderson . . . from Amherst to Acorn Park

◆ ◆ ◆

Archibald & Kendall, Inc., 481-487 Washington St., New York 13, N. Y., announces that their technical director, IFT member **Walter C. Hansen,** recently has been appointed to the Research Committee of the American Spice Trade Assn., Inc.

◆ ◆ ◆

Richard D. Boutros has been advanced from chief engineer to vice president and director of engineering at Mixing Equipment Co., Inc., 135 Mt. Read Blvd., Rochester, N. Y. Succeeding him as chief engineer is **Milton Dykman,** who had served as assistant chief engineer since 1951.

◆ ◆ ◆

Dr. Alfonso Cornejo of Mexico City has been appointed agent in Mexico for Evans Research and Development Corp., 250 E. 43rd St., New York 17, N. Y. Dr. Cornejo is a widely known consultant and professor at both the National University of Mexico and the National Polytechnic Institute of Mexico.

◆ ◆ ◆

George J. Madge, formerly comptroller of American Can Co., and a veteran of 44 years' service with the firm, has been elected a vice president in the executive department, and **John McCambridge,** formerly assistant comptroller of Canco, and with the company since 1920, has been appointed comptroller to succeed Mr. Madge.

◆ ◆ ◆

Dr. Lemuel D. Wright, director of research in microbiological chemistry at Merck Sharp and Dohme Research Laboratories, Philadelphia, has been named a professor of nutrition in Cornell University's Graduate School of Nutrition. The school offers graduate work leading to degrees in food science and nutritional science. Prof. Wright will work closely with **Dean Richard H. Barnes** in developing the school's research program. Prof. Wright has published more than 100 scientific papers.

LOOK TO TWITCHELL FOR

POWDERED CARAMEL COLOR

First introduced over 10 years ago, Twitchell's Caramel Color is now used by leading food manufacturers throughout the country. It is a clean, natural coloring, completely made from dextrose. Twitchell's Caramel Color is particularly suited for use in dry food preparations to produce a rich color, from a light tan to dark brown.

Typical Uses

- Powdered Desserts • Dehydrated Soups
- Dry Cake Mixes • Bouillon Powders
- Powdered Coffee and other beverages
- Powdered Gravy Seasonings

Write for Sample!

S. TWITCHELL CO.
CRESTMONT & HADDON AVES. • CAMDEN 4, N.J.

H. E. Woodford has been appointed president of Consolidated Food Processors, Inc., a subsidiary of Consolidated Foods Corp., Chicago. Upon assuming the presidency of Consolidated Food Processors, he will be nominated for election to the board of directors of the parent corporation.

Shown above examining a bottle of milk for radioactive contamination are 3 Veterinary Corps officers who recently completed a 6-week course in examination of food for radioactive contamination at Walter Reed Army Medical Center, Washington 12, D. C. Left to right: Maj. James M. Shively, Walter Reed; Lt. Col. Leslie Murphy, Walter Reed; and Lt. Col. Floyd C. Votaw, Sixth Army Area Medical Laboratory, Oakland, Calif.

◆ ◆ ◆

Gen. Lucius D. Clay, chairman of the board of Continental Can Co., 100 E. 42nd St., New York 17, N. Y., announced on November 23 that **George E. Dyke,** formerly chairman of the board and president of Robert Gair Co., Inc., which merged October 26 with Continental Can, has been elected vice chairman of the board of Continental. Three new vice presidents of Continental Can also were elected: **Raymond F. DeVoe** and **Norman F. Greenway,** former senior vice presidents of Gair; and **Robert L. Fitts,** previously a Gair vice president. Gen. Clay announced that the former activities of Robert Gair, together with Continental's paperboard and fibre drum divisions, will be administered under the general supervision of Mr. Dyke as vice chairman of the board. The newly named vice presidents will exercise their responsibilities within these general areas.

. . . high place at the board for CCC's Dyke

◆ ◆ ◆

Justin Schmit has been appointed vice president of operations of Chun King Sales, Duluth, Minn. Formerly assistant to the president, he now will be responsible for the areas of industrial relations, research, purchasing, and engineering at the Duluth and Jackson, Ohio, Chun King plants.

◆ ◆ ◆

Appointment of **Dr. Bernard S. Schweigert** as director of research and education of the American Meat Institute Foundation, 939 E. 57th St., Chicago, Ill., and **Drs. Delbert M. Doty** and **Chas. F. Niven, Jr.,** as associate directors has been announced by Wesley Hardenbergh, president of the non-profit scientific research organization at the University of Chicago.

ADVERTISERS' INDEX

American Maize Products Co. 21
Ass'n of American Soap & Glycerine Producers 29
Continental Can Company 11
Distillation Products Industries ..... 6 and 7
Dodge & Olcott, Inc. 15
Firmenich, Inc. 17
Florasynth Laboratories, Inc. 13
Food Development Laboratory 46
Food Machinery & Chemical Corp. 31
Fritzsche Brothers, Inc. 3
Froedtert Malt Corp. 33
Givaudan Flavors, Inc. 23
The Griffith Laboratories, Inc. ..... 3rd Cover
Klenzade Products, Inc. 36
Knickerbocker Mills Company 27
H. Kohnstamm & Company, Inc. 39
David Michael & Company, Inc. 41
Niagara Blower Company 5
Norda Essential Oil & Chemical Co. ..... 4th Cover
Chas. Pfizer & Company, Inc. ..... 2nd Cover
Proctor & Schwartz, Inc. 1
F. Ritter & Company 43
Schwarz Laboratories, Inc. 46
Sterwin Chemicals, Inc. 35
A. E. Staley Manufacturing Co. 22
Seaplant Chemical Corporation 42
Sunkist Growers, Inc. 9
Truesdail Laboratories, Inc. 46
S. Twitchell Company 44
Ungerer & Company, Inc. 24
van Ameringen-Haebler, Inc. 19
Vanilla Laboratories, Inc. 37
Wisconsin Alumni Research Foundation 46

TECHNICAL SERVICE REPRESENTATIVE

Well known Eastern food company is seeking to augment its Technical Service Division with an aggressive, personable, young Food Technologist or Food Chemist for technical service and sales liaison for all types of food manufacturing. Interest in sales engineering desirable.

Prefer man having up to 4 years experience in food industry. Position located in New York City. Some travel required. Salary commensurate with experience and qualifications.

Excellent opportunity—and future—for an ambitious man to work closely with top management. Company-Paid Employee and Family Security Benefits.

REPLIES HELD CONFIDENTIAL

Please send resumé with details of education, experience and salary requirements to:

Box FT 1914
125 West 41st Street, New York City

Reorganization of the Foundation's administrative staff was made necessary by the death of Dr. Henry R. Kraybill, noted scientist and educator, who had aided in the creation of the Foundation and had served as its director from 1947, when it first began operations. All three of the new administrative officers have held positions of research and administrative responsibility at the Foundation for eight or more years. All for several years served with Dr. Kraybill as assistant directors in charge of specific areas of research. All three hold professorial appointments at the University of Chicago.

Philip P. Gray, chief chemist of Wallerstein Laboratories since 1934, has been elected a vice president of Wallerstein Co., Inc., 180 Madison Ave., New York 16, N. Y.

◆ ◆ ◆

James E. Fike has joined Pennsalt Chemicals Company 3, Penn Center Plaza, Philadelphia 2, Pa., as a technical service engineer in the Chemical Specialties Division. In this capacity he will specialize in sales service on Pennsalt's line of B-K sanitation chemicals for milk producers and the dairy and food processing industries.

EMPLOYMENT NOTICES

WANTED: Food Technologist with experience in salad dressings, dehydrated soups, to take charge of production. Location Mexico City. Excellent opportunity for good man. Send resumé and salary requirements. REPLY BOX 515, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

The World Health Organization, Geneva, Switzerland, invites applications for the post of Scientist, Food Additives, which will become vacant in August 1957 at Headquarters in Geneva.

Required to plan and organize the collection and dissemination of chemical, physical and toxicological data relating to food additives; to give technical advice to Member States on this subject; to organize technical meetings and to collaborate with individuals and organizations working in this field.

B.Sc. or higher degree in food chemistry or related science from a recognized university; at least five years experience in a position requiring knowledge of food analysis and technical problems relating to food additives; preferably some knowledge of toxicological procedures and administrative and legislative problems relating to food additives; two-year contract in first instance; salary $7300 per annum, plus allowances and travel costs.

Apply in writing to the Personnel Office, World Health Organization, Palais des Nations, Geneva, not later than 1 February 1957, stating age, nationality, education and details of past and present employment.

EXPERIENCED FOOD TECHNOLOGIST—CHEMIST

Sales position—working with the food industries on new products and product improvements.

Excellent opportunity for an experienced technologist, food or cereal chemist. All replies confidential.

P. W. Bauman
MONSANTO CHEMICAL COMPANY
710 No. 12th Blvd.
St. Louis 1, Missouri

FOOD TECHNOLOGIST OR BACTERIOLOGIST—B.S. or M.S. Quality control, product development, and food research. Large food processor, central New York. Send resumé, salary requirements. REPLY BOX 513, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: FOOD TECHNOLOGIST. Ph.D. in chemistry desirable including background in industrial application, packaging and processing of foods. Involves staff supervision over extensive food and container program executed in field laboratories and under contract. Salary $8,900. Location Washington, D. C. REPLY BOX 517, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

CHEMICAL ENGINEERS
$6000-$9000

Excellent openings with multi-plant company in paper and plastics packaging, research and development, process and production of refrigerated foods and other food products. Employer pays our fee and expenses. Send resumé and photo to Mr. H. A. Jensen
WALKER EMPLOYMENT SERVICE
212 So. 7th St. Minneapolis 2, Minn.

FOOD PROCESSOR AND BUSINESSMAN. 28 yrs. exp. in managing large fruit processing plants in Europe and America. Chemist and technologist able to build, technically and commercially manage large plant. With excellent marketing connections. Specialist in apple industry (canned apples, juice, concentrate, esters, pectin). Seeks responsible position from July 1, 1957. REPLY BOX 514, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

FOOD TECHNOLOGISTS
An active, confidential service: Interview at your convenience. Call, write or wire:
Gladys Hunting (Consultant)
Drake Personnel, Inc.
Room 628
HArrison 7-8600
220 S. State St., Chicago 4, Ill.

AVAILABLE: Industrial Chemist-Engineer, B.S., post-graduate studies in food chemistry and bacteriology. Member IFT, ACS, AOCS. Completing foreign contract assignment for nationally-known research organization. Previously 15 yrs. production, control, research and development with major meat packer. Successful supervisory experience. REPLY BOX 518, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Ph.D. in radio-chemistry for staff duties connected with radiation preservation of foods and effects of radiation on non-food items of military significance. Involves staff supervision over extensive program. Salary in excess of $10,000 per annum. Location Washington, D. C. REPLY BOX 516, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

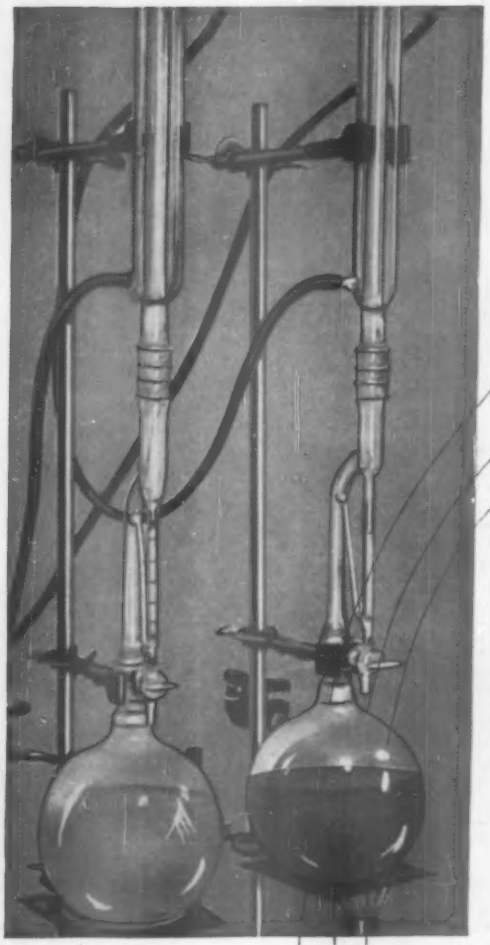
FOOD DEVELOPMENT LABORATORY
S. W. ARENSON
Director
2865 West Franklin St.
Baltimore 23, Md.
440 W. 24th St.
New York, N. Y.
Ingredient evaluations • New products development — flour, shortenings, milk and other basic ingredients • Chemical and physical laboratory, bakery, spray dryer and other unit process equipment.

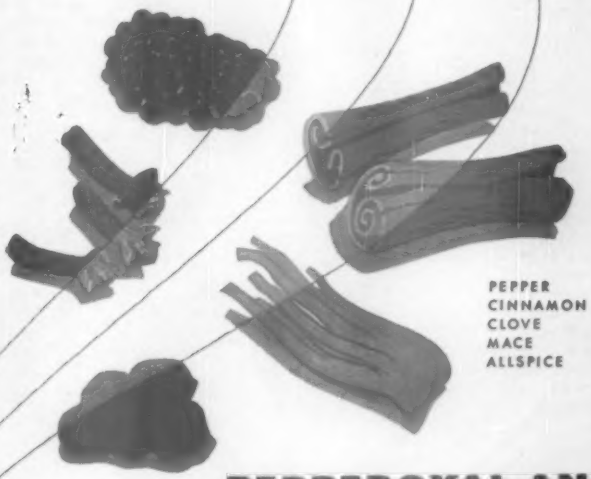
Schwarz
SERVICES TO THE FOOD INDUSTRIES
• Consultation on Food Problems.
• Analyses of food materials and products.
• Food plant design, process examination and control.
• Legal testimony and consultation on government regulations.
Founded 1867
Write for bulletin "Scientific Quality Control of Foods and Beverages"
SCHWARZ LABORATORIES, Inc.
230 Washington St., Mount Vernon, N. Y.

TRUESDAIL LABORATORIES, INC.
Chemists · Bacteriologists · Engineers
Request Brochure and Publication CHEMISTRY IN ACTION, on letterhead
1101 No. Figueroa Street, Los Angeles 65, California, CA 6-4148
HAWAIIAN DIVISION Honolulu, Hawaii
Research — Analyses — Testing
Foods — Drugs — Allied Products

WISCONSIN ALUMNI RESEARCH FOUNDATION
Projects, Consultation, and Production Control Services in Biochemistry, Chemistry, Bacteriology, Toxicology — Insecticide Testing — Flavor Evaluation
WRITE FOR PRICE SCHEDULE
WISCONSIN ALUMNI RESEARCH FOUNDATION
P.O. BOX 2217 • MADISON 1, WISCONSIN

The Taste of Sunshine—All the Time





PEPPER
CINNAMON
CLOVE
MACE
ALLSPICE

PEPPEROYAL AND SOLUBLIZED SEASONINGS

In this age of scientific miracles, Griffith's staff of chemists enable you to change a good product into a delicacy—simply by changing to PEPPEROYAL or SOLUBLIZED SEASONINGS.

Griffith's Solublized Seasoning formulas set a new high standard in flavor potency, purity and uniformity. By a special extraction process,* Griffith controls flavor quality. Blends spice extractives scientifically—with predictable, dependable results for spice users!

Change from the old to the new flavor quality—change to PEPPEROYAL OR SOLUBLIZED SEASONINGS.

Write us for details.

* PEPPEROYAL is a registered name.

The

GRIFFITH
LABORATORIES, Inc.

CHICAGO 9, 1415 W. 37th St. • NEWARK 12, 37 Empire St.
LOS ANGELES 58, 4900 Gifford Ave.

No other spray-dried flavors are more carefully guarded than Norda Nodes, to insure complete excellence, from starting spray to finished powder.

Nothing's known like Norda Nodes

. . . Spray-dried for you by Norda

Producing just-ordinary spray-dried flavors never would have interested Norda. That is why Norda developed Norda Nodes, and why Norda Nodes come only from Norda.

Norda men are flavor experts. It took their years of experienced skills to create the methods, help devise the machines, that make Norda Nodes possible.

Here are your true-fruit flavors, with every rich, real flavor essential locked ingeniously in tiny, colloid-coated "grains", that instantly flood foods with flavor when dry mixes are liquefied.

Uniform product flavor results. Flavors stay fresh and changeless, through much longer shelf life, and storage. Norda Nodes carry your quality through, from you to your customers.

Send your letterhead today for *free samples*.

"Flavor it with a Favorite"— Norda Nodes

Norda

Norda, Inc.
601 West 26th Street, New York, N. Y.

CHICAGO · LOS ANGELES · SAN FRANCISCO · TORONTO · MONTREAL · [illegible] · LONDON · PARIS · GRASSE · MEXICO CITY